NIAC
NASA Institute for Advanced Concepts

Annual Report

Visions of the Future in Aeronautics and space

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NASA Institute for Advanced Concepts
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An Institute of the

Universities Space Research Association

ANSER

USRA

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EXECUTIVE SUMMARY

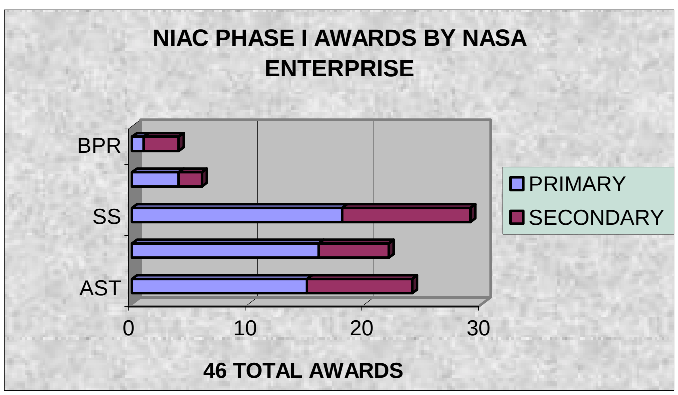
The NASA Institute for Advanced Concepts (NIAC) has completed the third full year of operation and all functions of the Institute have been fully implemented. During this third contract year, NIAC awarded 11 Phase II contracts totaling $5.3 million and 16 Phase I grants totaling $1.1 million. Since the beginning of the contract, NIAC has awarded 46 Phase I grants and 16 Phase II contracts for a total value of $8.6 million. These awards to universities, small businesses, small disadvantaged businesses and large businesses were for the development of revolutionary advanced concepts that may have a significant impact on future aeronautics and space missions. Based on the first 36 months of NIAC's operation, USRA has received an "excellent" rating from NASA in all categories of contract performance evaluation.

NIAC continues to encourage competitive proposals that relate to all NASA Enterprises. A strategy for attracting competitive proposals in all Enterprise areas evolves with each succeeding Phase I Call for Proposals. NIAC has aggressively targeted *visionary and emerging discovery* constituencies in the science and engineering community that may have a technical background to address the challenges of NASA programs and missions.

Table 1 lists all of the Calls for Proposals that have been issued by NIAC. A total of 337 Phase I and Phase II proposals have been received by NIAC and have resulted in 62 awards.

CALL #	TYPE OF CALL	RELEASE DATE	DUE DATE	AWARD DATE
CP 98-01	Phase I	June 19, 1998	July 31, 1998	November 1, 1998
CP 98-02	Phase I	November 23, 1998	January 31, 1999	May 1, 1999
CP 99-01	Phase II	February 3, 1999	May 31, 1999	August 1, 1999
CP 99-02	Phase II	July 27, 1999	January 9, 2000	April 11, 2000
CP 99-03	Phase I	September 20, 1999	January 31, 2000	May 1, 2000
CP 00-01	Phase II	May 26, 2000	November 30, 2000	March 1, 2001 (est)
CP 00-02	Phase I	September 22, 2000	February 18, 2001 (est)	May 1, 2001 (est)

Table 1. Summary of NIAC Calls for Proposals To Date



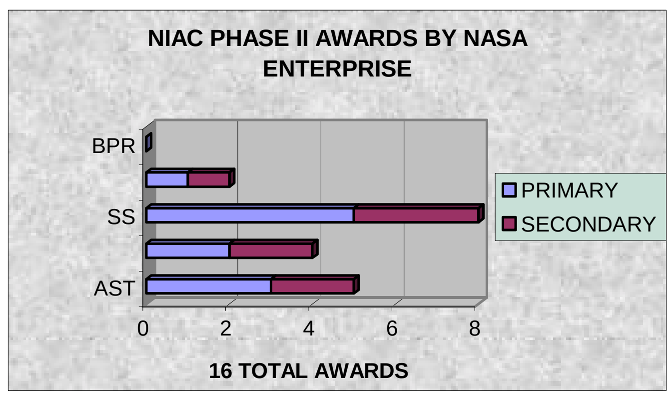


Figure 1. Summary of Phase I and Phase II awards' relationship to the NASA Enterprises

Figure 1 summarizes the relationship of the number of Phase I and Phase II awards to each of the NASA Enterprises through the first three years of operation. (BPR = Biology and Physical Research, ES = Earth Sciences, SS = Space Sciences, HEDS = Human Exploration and Development of Space, AST = Aerospace Technology). The Earth Sciences Enterprise area has received the lowest number of proposal responses, and this is reflected in the number of related awards. Other areas within each of the Enterprises were also targeted for increased emphasis. As a result of an analysis of proposal responses from the first two Phase I Calls and a recognition of emerging technical discoveries, the Phase I Call issued this year expressed a special interest in innovative responses related to Earth Sciences, Biology, HEDS, Aeronautics and Information Technology.

NIAC is open to all research business sectors and as a result, a broad cross-section of the science and engineering community has responded to the NIAC Calls as shown in Figures 2 and 3.

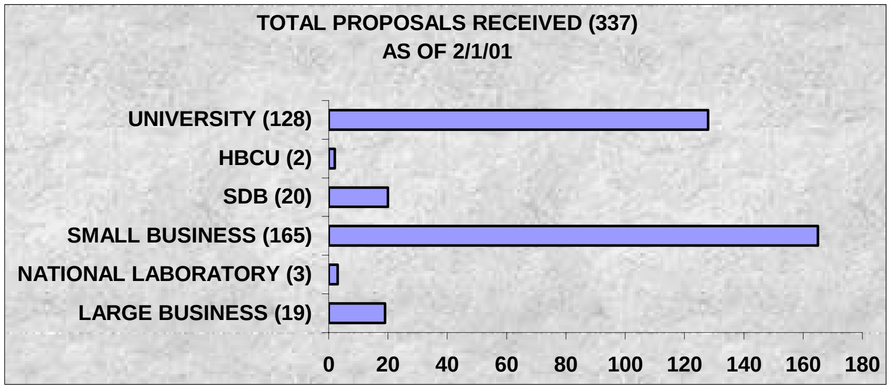


Figure 2. Proposals received in response to three Phase I Calls for Proposal

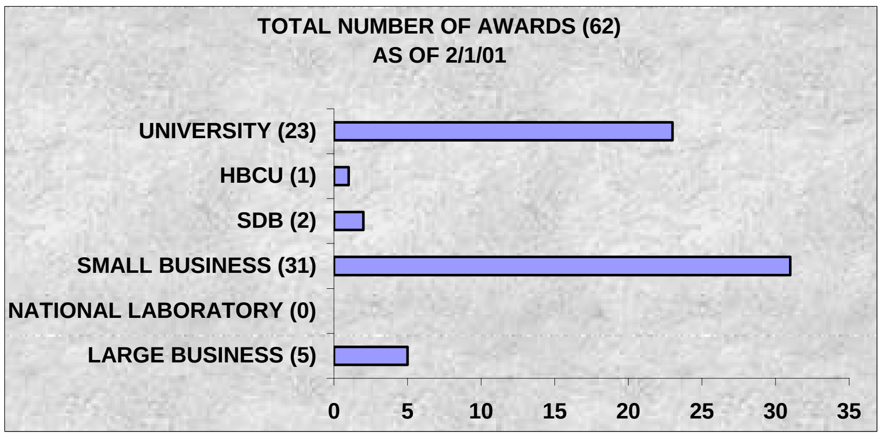


Figure 3. Awards to each business category

NIAC continued to reinforce a very productive atmosphere of open communication and feedback from the science and engineering community at large and from NASA researchers and managers at the Centers and Headquarters. This process is accomplished through the virtual operation of NIAC over the Internet, by hosting an annual meeting to showcase the concepts being funded by NIAC, and by conducting a workshop to inspire response from a broad cross-section of the research community. In addition, the NIAC Science, Engineering and Technology Council provides focused oversight and dedicated involvement that is especially supportive of the NIAC operation and future activities.

NIAC conducted Phase II site visits this year with the first set of contractors to complete their first year of Phase II development, and has successfully begun the process of infusing NIAC funded concepts into NASA programs for continuation funding.

During the next two years of the NASA contract, NIAC will continue to use the Phase I/Phase II selection strategy to competitively select advanced concepts with the greatest potential for significant impact. The technical themes chosen for annual meetings and workshops will give special emphasis to scientific discoveries and emerging technologies that could be the basis for inspiring interdisciplinary approaches to major challenges of aeronautics and space.

ACCOMPLISHMENTS

Summary

During the third year of operation, NIAC continued the processes that had been successfully established to inspire, select, fund and nurture revolutionary advanced concepts for aeronautics and space. Figure 4 summarizes the performance periods for completed and currently planned awards. The following sections describe the Calls that were awarded or initiated during the year's operation.

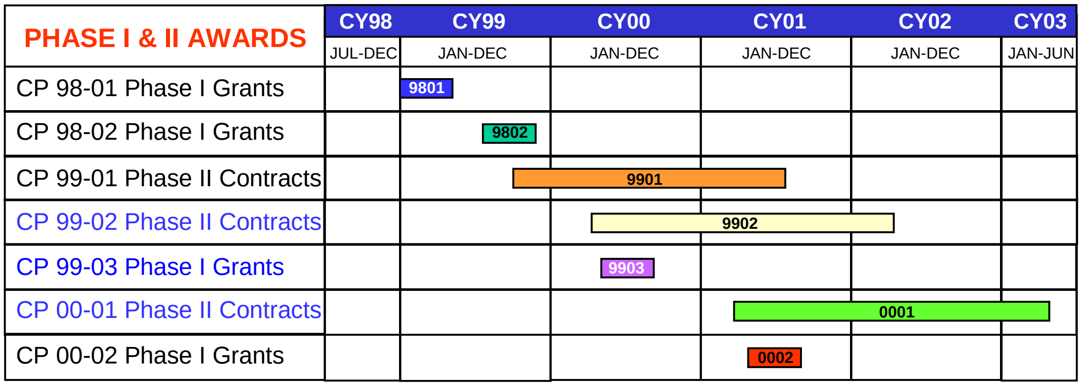


Figure 4. Phase I and Phase II Awards Performance Periods

Call for Proposals CP 99-02 (Phase II)

CP99-02 was a Phase II Call for Proposals that was released on July 27, 1999, to each of the Phase I grantees that had not previously received a Phase II contract. Fifteen proposals were received, thirteen from the CP 98-02 Fellows and two from the CP98-01 Fellows by the proposal due date of January 9, 2000. Table 2 summarizes the business categories of the respondents.

BUSINESS CATEGORY	CP 99-02 PROPOSALS
Universities	5
Historic Black Colleges & Universities and Minority Institutions	0
Small Disadvantaged Businesses	0
Small Business	9
National Labs	0
Large Business	1
TOTAL PROPOSALS RECEIVED FOR CP 99-02	**15**

Table 2. Summary of CP 99-02 Responding Organizations

Peer review of these proposals began during the second week of January 2000. Selection and final award of five contracts was made in April 2000. Table 3 summarizes the winning proposals selected for CP 99-02. Descriptions of these concepts are available on the NIAC website and in the Appendix.

PI NAME AND ORGANIZATION	ADVANCED CONCEPT PROPOSAL TITLE
CASH, WEBSTER *UNIVERSITY OF COLORADO*	X-Ray Interferometry
GRANT, JOHN *THE BOEING CORPORATION*	Hypersonic Airplane Space Tether Orbital Launch (HASTOL) Study
McNUTT, JR., RALPH *THE JOHNS HOPKINS UNIVERSITY*	A Realistic Interstellar Explorer
NOCK, KERRY *GLOBAL AEROSPACE CORPORATION*	Global Constellation of Stratospheric Scientific Platforms
RICE, ERIC *ORBITAL TECHNOLOGIES CORPORATION*	Advanced System Concept for Total ISRU-Based Propulsion and Power Systems for Unmanned and Manned Mars Exploration

Table 3. CP 99-02 Phase II Award Winners

Call for Proposals CP 99-03 (Phase I)

NIAC CP 99-03 was released on September 20, 1999, and 104 Phase I proposals were received by the January 31, 2000 due date. Table 4 summarizes the business category distribution of these 104 proposals.

BUSINESS CATEGORY	CP 99-03 PROPOSALS
Universities	33
Historic Black Colleges & Universities and Minority Institutions	2
Small Disadvantaged Businesses	8
Small Business	50
National Labs	0
Large Business	11
TOTAL PROPOSALS RECEIVED FOR CP 99-03	**104**

Table 4. Summary of CP 99-03 Responding Organizations

Peer review began in late January 2000. Grant awards were subsequently made to sixteen proposers in May 2000. Descriptions of these concepts are available on the NIAC website. The following Table 5 summarizes the winning proposals selected for CP 99-03:

PI NAME AND ORGANIZATION	ADVANCED CONCEPT PROPOSAL TITLE
NOCK, KERRY *GLOBAL AEROSPACE CORPORATION*	Cyclical Visits to Mars via Astronaut Hotels System
ENGLAND, CHRISTOPHER *ENGINEERING RESEARCH GROUP*	Mars Atmosphere Resource Recovery System (MARRS)
O'HANDLEY, DOUGLAS *ORBITAL TECHNOLOGIES CORPORATION*	System Architecture Development for a Self-Sustaining Lunar Colony
VANECK, THOMAS *PHYSICAL SCIENCES, INC.*	A System of Mesoscale Biomimetic Roboswimmers for Exploration and Search for Life on Europa
BROWN, CHRISTOPHER *DYNAMAC CORPORATION*	Programmable Plants: Development of an In Planta System for the Remote Monitoring and Control of Plant Function for Life Support
COLOZZA, ANTHONY *OHIO AEROSPACE INSTITUTE*	Planetary Exploration Using Biomimetics
POWELL, JAMES *PLUS ULTRA TECHNOLOGIES*	Development of Self-Sustaining Mars Colonies Utilizing the North Polar Cap and the Martian Atmosphere
MAISE, GEORGE *PLUS ULTRA TECHNOLOGIES*	Exploration of Jovian Atmosphere Using Nuclear Ramjet Flyer
IGNATIEV, ALEX *UNIVERSITY OF HOUSTON*	New Architecture for Space Solar Power Systems: Fabrication of Silicon Solar Cells Using In-Situ Resources
BOSTON, PENELOPE *COMPLEX SYSTEMS RESEARCH, INC.*	Scientific Exploration and Human Utilization of Subsurface Extraterrestrial Environments: A Feasibility Assessment of Strategies, Technologies & Test Beds
PALISOC, ARTHUR *L'GARDE INC.*	Large Telescope Using Holographically Corrected Membranes
VAN BUITEN, CHRIS *SIKORSKY AIRCRAFT INC.*	Autonomous VTOL Scalable Logistics Architecture
MACLAY, JORDAN *QUANTUM FIELDS LLC*	Feasibility of Communications Using Quantum Correlations
EDWARDS, BRADLEY CARL *EUREKA SCIENTIFIC*	The Space Elevator
TYLL, JASON *GASL, INC.*	Environmentally-Neutral Aircraft Propulsion Using Low Temperature Plasmas
MOLNAR, PETER *CLARK ATLANTA UNIVERSITY*	Self-Organized Navigation Control for Manned and Unmanned Vehicles in Space Colonies

Table 5. CP 99-03 Phase I Award Winners

Call for Proposals CP 00-01 (Phase II)

Release of Phase II CP 00-01 on May 26, 2000, resulted in 19 proposals received on November 30, 2000. Table 6 summarizes the business category distribution of these 19 proposals.

Business Category	CP 00-01 Proposals
Universities	1
Historic Black Colleges & Universities and Minority Institutions	0
Small Disadvantaged Businesses	1
Small Business	16
National Labs	0
Large Business	1
TOTAL PROPOSALS RECEIVED FOR CP 00-01	19

Table 6. Summary of CP 00-01 Responding Organizations

The peer review of this Call commenced shortly after the proposals were received on November 30, 2000. Five proposals were selected for contracts to begin around March 2001. Descriptions of these concepts are available on the NIAC website and in the Appendix. A summary of the winners follows in Table 7:

PI Name and Organization	Advanced Concept Proposal Title
Nock, Kerry *Global Aerospace Corporation*	Cyclical Visits to Mars via Astronaut Hotels System
Maise, George *Plus Ultra Technologies, Inc.*	Exploration of Jovian Atmosphere Using Nuclear Ramjet Flyer
Keith, Andrew *Sikorsky Aircraft Corporation*	Methodology for Study of Autonomous VTOL Scalable Logistics Architecture
Edwards, Bradley Carl *Eureka Scientific*	The Space Elevator
Colozza, Anthony *Ohio Aerospace Institute*	Planetary Exploration Using Biomimetics

Table 7. CP 00-01 Phase II Award Winners

Call for Proposals CP 00-02 (Phase I)

This Phase I solicitation was released on September 22, 2000, with a proposal due date of February 18, 2001. The results of this Call will be reported in next year's annual report.

Phase II Site Visits

All Phase II contracts require that the PI host a site visit during the ninth or tenth month of the first year of the contract. Site visits were conducted with the following Phase II contractors. NIAC and NASA attendees are noted in Table 8:

Site Visit	PI Name	Dates	Attendees
MIT	Dubowsky	May 10, 2000	Bob Cassanova and Hal Aldridge (JSC)
Smithsonian Institution Astrophysical Observatory	Gorenstein	May 11, 2000	Bob Cassanova, Jim Bilbro (MSFC) and Will Zhang (GSFC)
Tethers Unlimited	Hoyt	May 25, 2000	Bob Cassanova and Dennis Gallagher (MSFC)
University of Washington	Winglee	May 26, 2000	Bob Cassanova and Dennis Gallagher (MSFC)
University of Arizona	Woolf	June 22, 2000	Bob Cassanova and Jesse Leitner (GSFC)
Stanford University	Kroo	June 27, 2000	Bob Cassanova, Jerry Malcolm (DFRC), Larry Young (ARC) and Bill Warmbrodt (ARC)

Table 8. Phase II Site Visits

As part of normal contract management activity, NIAC conducts site visits at all of the Phase II contractors' locations near the end of the first year of their Phase II contract and before exercising the contract option on the remainder of the Phase II activity. In addition to the attendance of the NIAC Director, other persons attending may include Ms. Sharon Garrison (NIAC COTR), NIAC technical consultants and representatives from NASA HQ and Centers. The purpose of these site visits is to review the status and plans for development of the advanced concepts and to begin exploring the possibility of follow-on funding after the Phase II contract. Scheduled site visits for the CP 99-02 Phase II contracts are as follows:

Ralph McNutt, Jr., Johns Hopkins University Applied Physics Lab - *January 25*
John Grant, Boeing - *February 7*
Kerry Nock, Global Aerospace Corporation - *February 8*
Webster Cash, University of Colorado - *February 13*
Eric Rice, Orbital Technologies Corporation – *March 8*

Infusion of Advanced Concepts into NASA

The primary purpose of NIAC is to provide leadership to inspire advanced concepts, solicit, select, fund and nurture advanced concepts that may have significant impact on future NASA missions and programs. After a concept has been developed and matured through the NIAC process, it is NASA's intent that the most promising concept will be transitioned into NASA's program for additional study and follow-on funding. NIAC has taken a proactive approach to this infusion process. In addition to the routine activities to maintain public awareness and visibility for all of the NIAC advanced concepts, NIAC orchestrates the following activities:

- Conducts status and visibility briefings with NASA researchers and managers
- Invites NASA leaders to Phase II site visits to participate in status and planning discussions
- Provides names of key NASA contacts to NIAC Fellows
- Encourages NIAC Fellows to publish their work in technical society meetings and technical journals

By the end of this contract year, a number of concepts have successfully begun the process of transitioning back to NASA and some have obtained funding from other sources. Table 9 reports the status of those concepts that have begun the transition process.

PHASE I		
PI Name	**Concept Title**	**Director Comments**
BEKEY	A Structureless Extremely Large Yet Very Lightweight Swarm Array Space Telescope	98-01 Phase I only. Funded by another government agency.
LANDIS	Advanced Solar- and Laser-Pushed Lightsail Concept	98-02 Phase I only. Co-PI funded by JPL for microwave powered light sail experiment.
IGNATIEV	New Architecture for Space Solar Power Systems: Fabrication of Silicon Solar Cells Using In-Situ Resources	99-03 Phase I. Awarded Cross-Enterprise contract for related technology.
PHASE II		
DUBOWSKY	Self-Transforming Robotic Planetary Explorers	99-01 Phase II. PI feels NASA reception indicates that concept is too advanced for their current program plans.
GORENSTEIN	An Ultra High Throughput X-Ray Astronomy Observatory with A New Mission Architecture	99-01 Phase II. In touch with MSFC and GSFC. New development in X-ray interferometry may supercede.
KROO	The Mesicopter: A Meso-Scale Flight Vehicle	99-01 Phase II. Strong interest by ARC. Considering follow-on funding.
WOOLF	Very Large Optics for the Study of Extrasolar Terrestrial Planets	99-01 Phase II. Strong collaboration with MSFC and GSFC. Directly connected to Life Finder mentioned in OSS Strategic Planning and Decadel Planning.
HOYT	Moon & Mars Orbiting Spinning Tether Transport Architecture Study	99-01 Phase II. Strong collaboration with MSFC. Funding for momentum exchange tethers in MSFC plan for 00-02. Recently awarded Cross-Enterprise subcontract for related technology.
WINGLEE	Mini-Magnetospheric Plasma Propulsion, M^2P^2	99-01 Phase II. Additional funding awarded for MSFC test program. MSFC systems analysis underway. Top contender for radiation shielding concept. Propulsion and radiation shielding concepts briefed to Goldin and Decadel Planning. Budget allocated for follow-on tests and systems analysis.
CASH	X-Ray Interferometry	99-02 Phase II. Strong collaboration with GSFC. Directly connected with MAXIM mentioned in OSS Strategic Planning and Decadel Planning process.
GRANT	Hypersonic Airplane Space Tether Orbital Launch (HASTOL) Study	99-02 Phase II. Directly associated with Hoyt concept development.
McNUTT, JR.	A Realistic Interstellar Explorer	99-02 Phase II. Connected to potential follow-on to JPL Interstellar Mission. PI on JPL working group. Awarded Cross-Enterprise contract for related technology.
RICE	Advanced System Concept for Total ISRU-Based Propulsion & Power Systems for Unmanned and Manned Mars Exploration	99-02 Phase II. In communication with JSC.
NOCK	Global Constellation of Stratospheric Scientific Platforms	99-02 Phase II. In communication with GSFC and Wallops. Awarded SBIR contract in related subsystem.

Table 9: Status of Infusion of Concepts into NASA

Coordination with NASA

Sharon M. Garrison is the NASA Coordinator for the NIAC in the Aerospace Technology Office (ATO) of the NASA Technology Integration Division (NTID) at GSFC. She is the primary point of contact between NIAC and NASA. Ms. Garrison actively communicates throughout NASA to a review team comprised of representatives from the Enterprises, Centers and Office of the Chief Technologist. Table 10 is a listing of these representatives. Throughout the process of managing NIAC, these representatives have been kept informed via Ms. Garrison of the status of the Institute and have been appropriately involved in decisions and feedback. The NIAC provides monthly contract status reports and an Annual Report to the NASA Coordinator who forwards the reports to the Support Team and others within NASA.

NASA COTR	NASA Office of the Chief Technologist	NASA Enterprises	Centers
Sharon Garrison, GSFC	Murray Hirschbein, R	John Mankins, M Karl Loutinsky, R Glenn Mucklow, S Alex Pline, U Gordon Johnston, Y	Larry Lasher, ARC Steve Whitmore, DFRC Daniel Glover, GRC Dennis Andrucyk, GSFC Art Murphy, JPL Ken Cox, JSC Gale Allen, KSC Dennis Bushnell, LaRC John Cole, MSFC Bill St. Cyr, SSC

Table 10. NASA NIAC Support Team

Very early in the start-up process of the Institute, Dr. Cassanova and Ms. Garrison visited NASA Associate Administrators of the Strategic Enterprises and Center Directors to brief them on the plans for NIAC and to seek their active support and feedback. During the second year of NIAC's operation, Dr. Cassanova revisited all the Centers to update the status of the NIAC and to conduct technical discussions with Center staff. Visits during the third year were targeted to achieve specific communication with NASA managers and technical staff related to current and future NIAC concepts. Visits to NASA organizations during the third year are listed in Table 11. Visits to NASA Headquarters included meetings with Associate Administrators, Theme Managers and other senior staff.

NASA Organization	Dates of Visits	Purpose of Visits
Headquarters	March 7, 2000	Participate in the Space Science Technology Management and Operations Working Group
GSFC	April 3, 2000	Director met with GSFC coordinator of Engineering Colloquia Series to discuss NIAC Fellow presentations at future colloquia
Headquarters	April 3-4, 2000	Coordination with Offices of Space Sciences, Earth Sciences and Human Exploration and Development of Space
Headquarters	May 12, 2000	Coordination with Offices of Space Sciences, Human Exploration and Development of Space, and Aeronautics Technology
JSC	October 23-24, 2000	Coordination with JSC and to present NIAC Status Overview
MSFC	November 3, 2000	Coordination with MSFC Integrated Technology Assessment Center program representatives at NIAC
Headquarters	December 4, 2000	Director met with Earth Sciences Enterprise representative at NIAC
Headquarters	January 24, 2001	Coordination with Biology and Physical Research Enterprise
LaRC	January 25, 2001	Coordination with NASA LaRC Revolutionary Advanced Systems Concepts program representatives

Table 11. NASA Visits

In addition to the periodic coordination visits to Headquarters and the Centers, the NIAC Director has been invited to participate in a number of planning and oversight groups organized by NASA. Currently, the NIAC Director is a member of the Space Science Technology Management and Operations Working Group (SSTMOWG) that meets approximately every three months.

Second NIAC Annual Meeting

The Second NIAC Annual Meeting was held at NASA Goddard Space Flight Center in the Building 3 Auditorium on June 6-7, 2000. There were 166 pre-registered guests, and 110 actually attended. The meeting activities included an informal reception on the evening of June 6th. All currently funded Phase I and Phase II NIAC Fellows gave an overview of their advanced concepts and responded to questions and comments from the audience. The audience included a broad cross-section of the research community (NASA Centers, small and large businesses, and universities) and students from the science and technology programs of high schools in proximity to GSFC.

NIAC Workshop

"Innovation at the Interface of Scientific Disciplines: Redefining the Possibilities in Aeronautics and Space" was the theme of the workshop which was held November 7-8, 2000 in Atlanta. The primary purpose of the workshop was to inspire innovative and visionary ideas from the scientific disciplines that are not normally focused on aerospace challenges. New visions of the possible or challenges of the seemingly impossible emerging from the NIAC workshop may serve to inspire innovative, revolutionary concepts at the interface of traditional scientific disciplines.

The workshop included keynote speakers to provide a general overview of selected areas and workshop sessions focused on specific areas of emphasis. Workshop sessions included panels of established researchers to assist in catalyzing vigorous discussions. The sessions were designed to promote a vigorous, unbiased forum for interchange of ideas, concepts, perspectives of emerging technologies, challenges of aerospace endeavors and visions of emerging possibilities.

The workshop keynote speakers were:

Mr. Gentry Lee, Aerospace Consultant and Author
Discoveries at the Interface of Scientific Disciplines

Dr. George Donohue, George Mason University
Air Transportation is a Complex, Adaptive System, Not an Airplane

Dr. Kenneth Nealson, California Institute of Technology
Things We Thought Couldn't Exist and Where They Lead Us

Dr. Mark Abbott, Oregon State University
Earth Science and Technology – Challenges and Opportunities in 2020

Dr. Kathryn Clark, Chief Scientist for HEDS, NASA Headquarters
Exploring the Cosmos, Getting There from Here

Breakout sessions were conducted on the following topics:

- Air and Space Transportation
- Earth Sciences
- Life Sciences and Biology

Presentations by keynote speakers and panelists, if available electronically, are now posted on the NIAC website. A short summary of the recommendations from the workshop sessions and the attendee list are also posted.

Participation in Technical Society Meetings, Workshops and National Research Council Boards

In order to expand and maintain NIAC's visibility, NIAC was represented at technical society meetings, technical workshops and at one of the National Research Council Boards as summarized in Table 12.

MEETING	DATES	SPONSOR	NIAC FUNCTION
National Research Council Space Studies Board	March 7, 2000	NRC	Director gave status briefing
Turning Goals into Reality	May 18-19, 2000	NASA	Director attended
Workshop on Concepts and Approaches for the Robotic Exploration of Mars	July 18-20, 2000	NASA	ANSER represented NIAC
HEDS Technology/Commercialization Workshop	July 21 – August 2, 2000	NASA KSC	NIAC Overview presented by Ken Cox
Radiation Shielding Workshop	September 18-19, 2000	NASA MSFC	Director participated in advanced planning for radiation shielding
Seminar at the Institute for Paper Science and Technology	October 6, 2000	Institute for Paper Science and Technology	Director gave NIAC Overview
Space and Astronomy Day at NASA GSFC	October 21, 2000	NASA GSFC	ANSER representative participated and gave paper
Fall Meeting of the Aerospace Technology Working Group	November 14-16, 2000	NASA KSC and LaRC	Director gave NIAC overview
Earth Sciences Technology Workshop	January 23-24, 2001	NASA	Director attended

Table 12. NIAC Participation in Technical Meetings

Public Relations

In addition to the ongoing publicity through the NIAC website, NIAC activities have been the subject of articles in publications serving the general public and the technical community.

Several articles about NIAC and its sponsored advanced concepts were published in June and July:

- *Introducing the NASA Institute for Advanced Concepts*, by Dr. Robert A. Cassanova, Newsletter of the American Society for Gravitational and Space Biology, Spring, 2000. http://www.asgsb.org
- *Resurrecting the Vision*, by Dr. Jerry Grey, Spacenews.com, July 10, 2000. http://spacenews.com
- *Stranger than Fiction,* by Sanjida O'Connell, The Guardian, July 27, 2000. http://www.guardianunlimited.co.uk/

A news article entitled "*One Giant Leap for Lunar Cells"* appears in the August 2000 issue of PHOTON International – The Photovoltaic magazine describing the NIAC funded Phase I activities at the University of Houston. The University of Houston Phase I project, "New Architecture for Space Power Systems: Fabrication of Silicon Solar Cells Using In-Situ Resources", is led by Drs. Alex Ignatiev and Alex Freundich.

Dr. Webster Cash, a Phase II Fellow at the University of Colorado, gave an invited talk on x-ray interferometry at the XXIVth General Assembly of the International Astronomical Union (IAU) in Manchester UK. Dr. Nick Woolf, Phase II Fellow at the University of Arizona, also gave a presentation. The IAU meeting took place August 7-18.

Dr. Cassanova was contacted by Trish Mitchell of the Discovery Channel who is preparing a program for next year on the general subject of "2001: A Space Odyssey" based on the book by Sir Arthur C. Clarke. She is considering using some of the NIAC concepts as examples of the idea whereas, at one time would have been considered science fiction, are now closer to reality. She was given contact information for some of the NIAC Fellows and other persons who have worked with NIAC.

The concept being developed by Alex Ignatiev, Phase I Fellow, was described in an article in PHOTON International, The Photovoltaic magazine in the August, 2000 issue, pp. 6-7.

On September 13, 2000, an article entitled "*New X-Ray Telescope Technology Propels Virtual Journey to Black Hole*" appeared on the NASE website, NASA News. NIAC Fellow, Dr. Webster Cash at the University of Colorado, is currently developing this concept. A related article was published in the September 14 issue of Nature authored by Dr. Cash and several co-authors.

Dr. Robert Hoyt, Phase II Fellow, and Dr. Robert L. Forward, Tethers Unlimited Incorporated (TUI) Chief Scientist, participated in the Tether Technology Workshop at the AFRL in Kirtland AFB, New Mexico on September 6-7. Dr. Forward briefed the workshop on TUI's progress on momentum-exchange tether technologies, while Dr. Hoyt summarized TUI's work on small electrodynamic tether systems.

John E. Grant, Phase II Fellow, presented a description of the NIAC advanced concept, *Hypersonic Airplane Space Tether Orbital Launch* (HASTOL), at the AIAA Space 2000 Conference in Long Beach, California, on September 21. The paper is included in a session chaired by Mr. Gary Lyles from NASA Marshall Space Flight Center, Huntsville, Alabama.

On October 4, 2000, an article entitled *"Hitching a Ride on a Magnetic Bubble"* was published on the NASA website, Science@NASA. The subject of the article is the M^2P^2 concept being developed by NIAC Fellow, Dr. Robert Winglee at the University of Washington. Dr. Winglee and Dr. Dennis Gallagher at MSFC have just completed a test program in one of the vacuum chambers at MSFC.

On October 11, 2000, an article by Gentry Lee entitled "*Concepts for the Future*" appeared on the Space.com website. The article described several NIAC funded concepts that have captured the imagination of the scientific community. The article contains the following statement:

> ***"The outstanding early accomplishments of NIAC are a tribute both to the helmsmanship of the Institute's director, Dr. Bob Cassanova, and to the vision of the top NASA executives who conceived the idea for an independent institute of advanced concepts in the first place."***

The American Society for Gravitational and Space Biology held a joint scientific meeting with the Canadian Space Agency and the European Low Gravity Research Association on October 25-28 in Montreal, Canada. The ASGSB newsletter distributed at the meeting contained an article about NIAC that mentioned the release of the Phase I Call for Proposals, CP00-02 and the upcoming NIAC workshop in Atlanta.

The December 2000 issue of *AIAA Aerospace America*, pp. 54-55, mentions several projects funded by NIAC. The article was written by George Schmidt, MSFC, who had received input from NIAC. NIAC concepts mentioned were:

- *Mini-Magnetospheric Plasma Propulsion*, University of Washington
- *A Realistic Interstellar Explorer*, Johns Hopkins University Applied Physics Lab
- *Moon and Mars Orbiting Spinning Tether Transport*, Tethers Unlimited
- *Hypersonic Airplane Space Tether Orbital Launch*, Boeing
- *Advanced System Concept for Total ISRU-Based Propulsion & Poser Systems for Unmanned and Manned Mars Exploration*, Orbital Technologies Corporation
- *Microwave Propelled Lightsail* which is based on the Phase I work by Geoffrey Landis at the Ohio Aerospace Institute on the concept of *Advanced Solar and Laser Lightsail Concepts*. Dr. Landis is now a member of the research staff at NASA GRC.

The December 2nd issue of the New Scientist (pages 32-35) contains an article about the NIAC sponsored concept, the Nuclear Ramjet Flyer, being developed by James Powell and George Maise at Plus Ultra.

There was an article written about the Phase I "Programmable Plants" concept being developed by Chris Brown appearing in the December 9 issue of *New Scientist*. The text for the article can be found at *http://www.newscientist.com/features/features_226846.html.*

Sir Clarke wrote an article that was published in the January 2001 issue of *Playboy* in which reference is made to NIAC:

> ***"And sooner or later the noisy and inefficient rocket will be superseded by something better. NASA's recently established Institute for Advanced Concepts is looking at a whole range of future possibilities — even the fabled "space drive" beloved by science fiction writers. Perhaps the rocket will play the same role in space that the balloon did in the air."***

A representative from Italian Public TV asked Dr. Cassanova for an interview for a special program on the subject of space travel in 2001, commemorating Sir Arthur C. Clarke's book "2001: A Space Odyssey". The interview is planned for early February, 2001.

Inputs to NASA Technology Inventory Database

NIAC provides input to the NASA Technology Inventory Database immediately after awards for Phase I or Phase II concepts are announced. The public version of this database, which is maintained by NASA GSFC, is available at http://technology.gsfc.nasa.gov/technology/.

Financial Performance

NIAC strives to minimize its operational expenses in order to devote maximum funds to viable advanced concepts. For the third straight year, this objective has been met as evidenced in Figure 5. Calendar year three actual results indicate 81.5% of NIAC's total budget was devoted to advanced concept research. The ambitious goal in the NIAC contract of 81% has been achieved in all three contract years. No doubt this trend will continue with the obligation of funds for CP 00-01 and CP 00-02 in the first and second quarter of calendar year four.

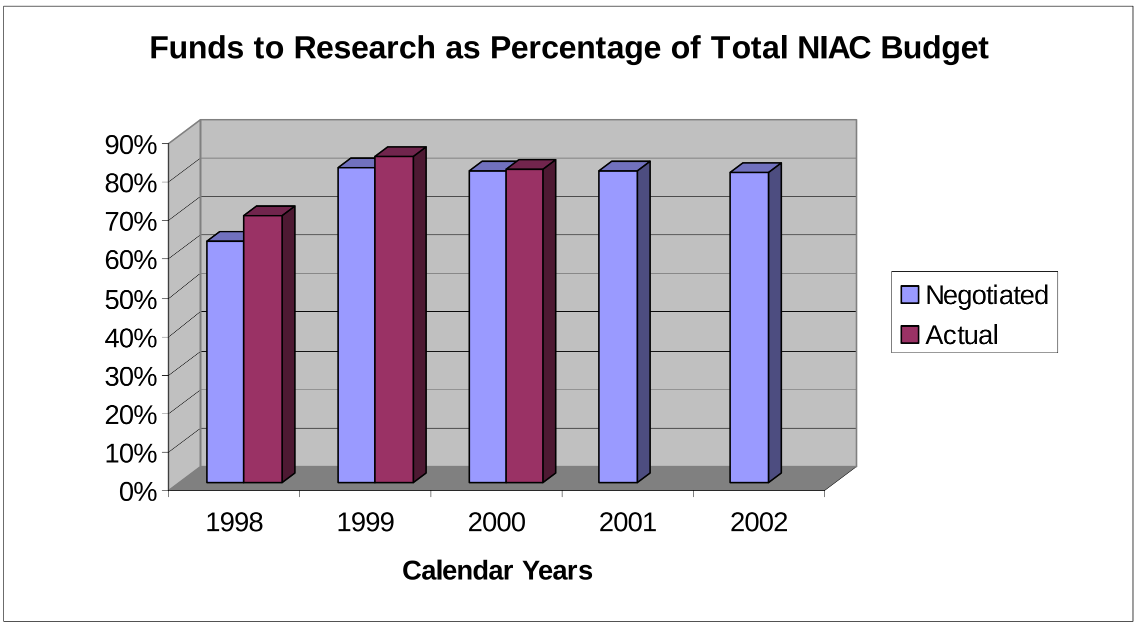


Figure 5. Funds to Research as Percentage of Total NIAC Budget

Note: Actual percentages are determined by dividing total annual research obligations by the sum of total actual annual NIAC operations expenses and total annual research obligations. Actual research award amounts reflect obligations through CP99-03.

DESCRIPTION OF THE NIAC

Mission

The NASA Institute for Advanced Concepts (NIAC) has been formed for the explicit purpose of being an independent source of revolutionary aeronautical and space concepts that could dramatically impact how NASA develops and conducts its mission. The Institute is to provide highly visible, recognized and high-level entry point for outside thinkers and researchers. The ultimate goal of NIAC is to infuse NIAC funded advanced concepts into future NASA plans and programs. The Institute functions as a **virtual** institute and uses resources of the Internet whenever productive and efficient for communication with grant recipients, NASA, and the science and engineering community.

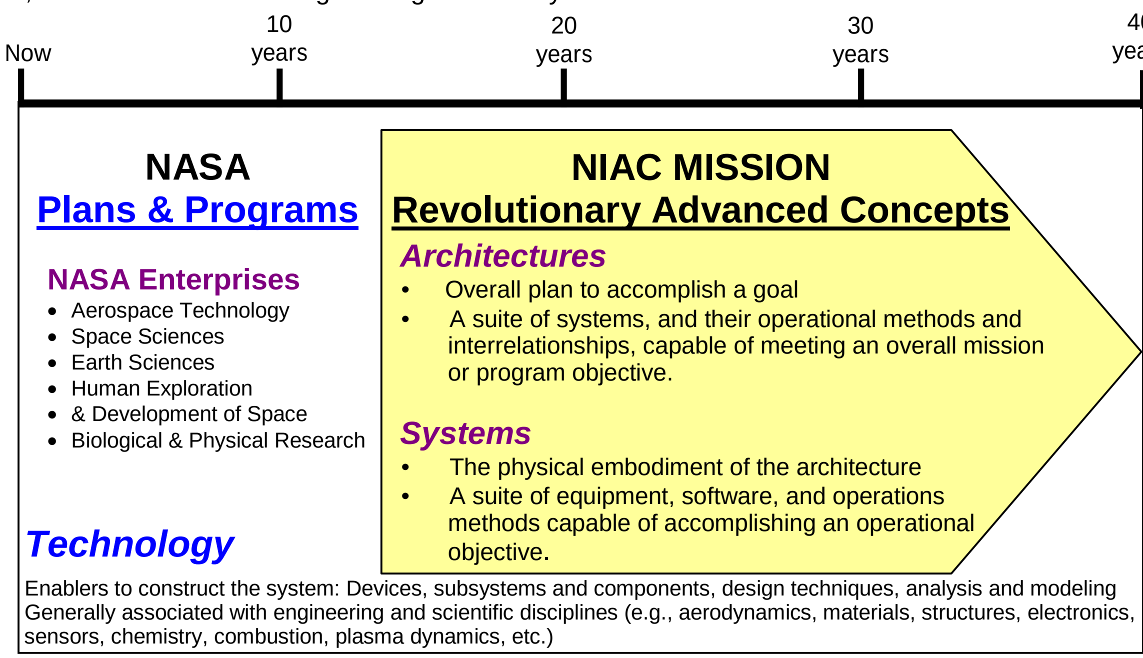


Figure 6. NIAC Mission

Figure 6 illustrates the mission of NIAC relative to the NASA plans and programs and the ongoing technology development efforts. The purpose of NIAC is to provide an independent, open forum for the external analysis and definition of space and aeronautics advanced concepts to complement the advanced concepts activities conducted within the NASA Enterprises. The NIAC has advanced concepts as its sole focus. It focuses on revolutionary concepts - specifically systems and architectures - that can have a major impact on missions of the NASA Enterprises in the time frame of 10 to 40 years in the future. It generates ideas for how the current NASA Agenda can be done better; it expands our vision of future possibilities. The scope of the NIAC is based on the National Space Policy, the NASA Strategic Plan, the NASA Enterprise Strategic Plans and future mission plans of the NASA Enterprises, but it is bounded only by the horizons of human imagination.

Organization

The NIAC organization is illustrated below in Figure 7. As an Institute of the Universities Space Research Association (USRA), NIAC reports to the President of USRA.

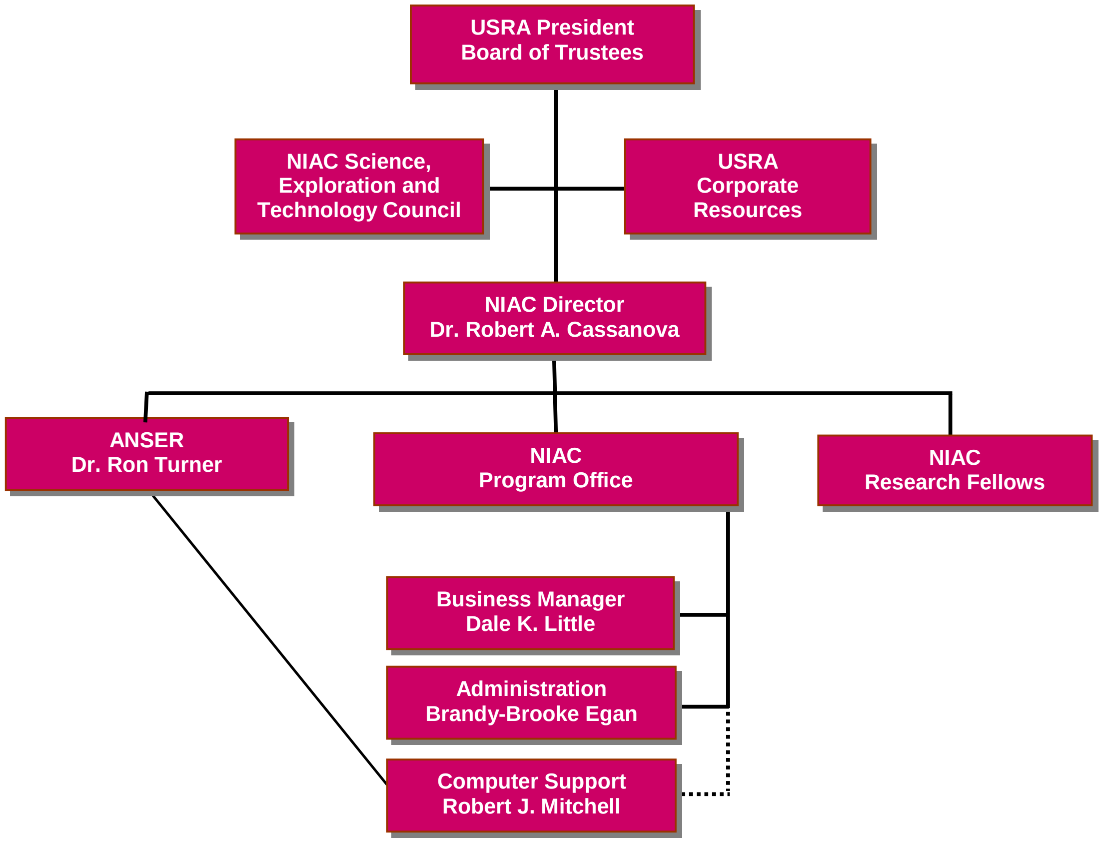


Figure 7. NIAC Organization

The NIAC staff is located at the NIAC HQ office in Atlanta, Georgia, and consists of its director, business manager and administrative assistant. An additional staff member was added by ANSER in March 1999 to provide full-time computer network and software application support at NIAC HQ.

Recipients of NIAC grant or contract awards are designated as "NIAC Fellows."

ANSER, through a subcontract from the USRA/NIAC, provides program support, technical support and information technology support for NIAC's operation. ANSER actively participated in NIAC program reviews and planning sessions, proposal peer reviews, source selection activities, and concurrence meetings. ANSER is responsible for maintaining an understanding of ongoing funded studies and the relationship of these studies to other work underway or previously considered by the aerospace community. To meet this challenge, ANSER reviews aerospace technology databases, conducts on-line data searches, and completes short assessments as needed to identify the status of technologies related to proposed and ongoing studies. This information is used in direct support of the peer review and selection processes as well as the management function of conducting site visits. To help maintain an understanding of the relevance of potential studies to current and potential NASA enterprises and understanding the relevance of potential studies to current and potential NASA Enterprises and Missions, ANSER attends NIAC meetings with NASA Associate Administrators. ANSER periodically reviews the NIAC website technical content. The periodic review of the website ensured the integrity and timeliness of the posted data and provided an opportunity to add interesting links to related sites maintained by NASA and the aerospace community.

As a corporate expense, USRA formed the NIAC Science, Exploration and Technology Council to oversee the operation of NIAC on behalf of the relevant scientific and engineering community. The Council is composed of a diverse group of thinkers, eminent in their respective fields and representing a broad cross-section of technologies related to the NASA Charter. The Council has a rotating membership with each member serving a three-year term. The USRA Board of Trustees appoints council members.

The current membership of the NIAC Science, Exploration and Technology Council is as follows:

Dr. Burton Edelson, George Washington University (Convener)
Dr. David Black, Lunar and Planetary Institute
Dr. Jerry Grey, Aerospace Consultant
Mr. Gentry Lee, Aerospace Consultant and Author
Dr. Lynn Margulis, University of Massachusetts
Dr. Mark Abbott, Oregon State University
Dr. Taylor Wang, Vanderbilt University
Dr. Peter M.Banks, University of Michigan
Dr. George L. Donohue, George Mason University
Dr. John V. Evans, COMSAT Corporation
Dr. Robert E. Whitehead, Aerospace Consultant
Dr. Robert A. Cassanova, NASA Institute for Advanced Concepts (*ex officio*)

Dr. David Black was recently named President of USRA, and will be replaced in March 2001.

Facilities

NIAC Headquarters is centrally located in midtown Atlanta, Georgia. It occupies 2,000 square feet of professional office space, with access to two conference rooms onsite as well as a 75-seat auditorium. The staff is linked via a Windows NT based Local Area Network (LAN) consisting of 5 Pentium II PCs, one Macintosh G3 and two Unix servers. Internet access is provided via a fiber-optic link through the Georgia Tech network. Other equipment includes a flat-bed scanner, an HP Color LaserJet 5 printer, an HP LaserJet 4000TN printer, an HP LaserJet 3100 fax machine and a Canon NP6050 copier.

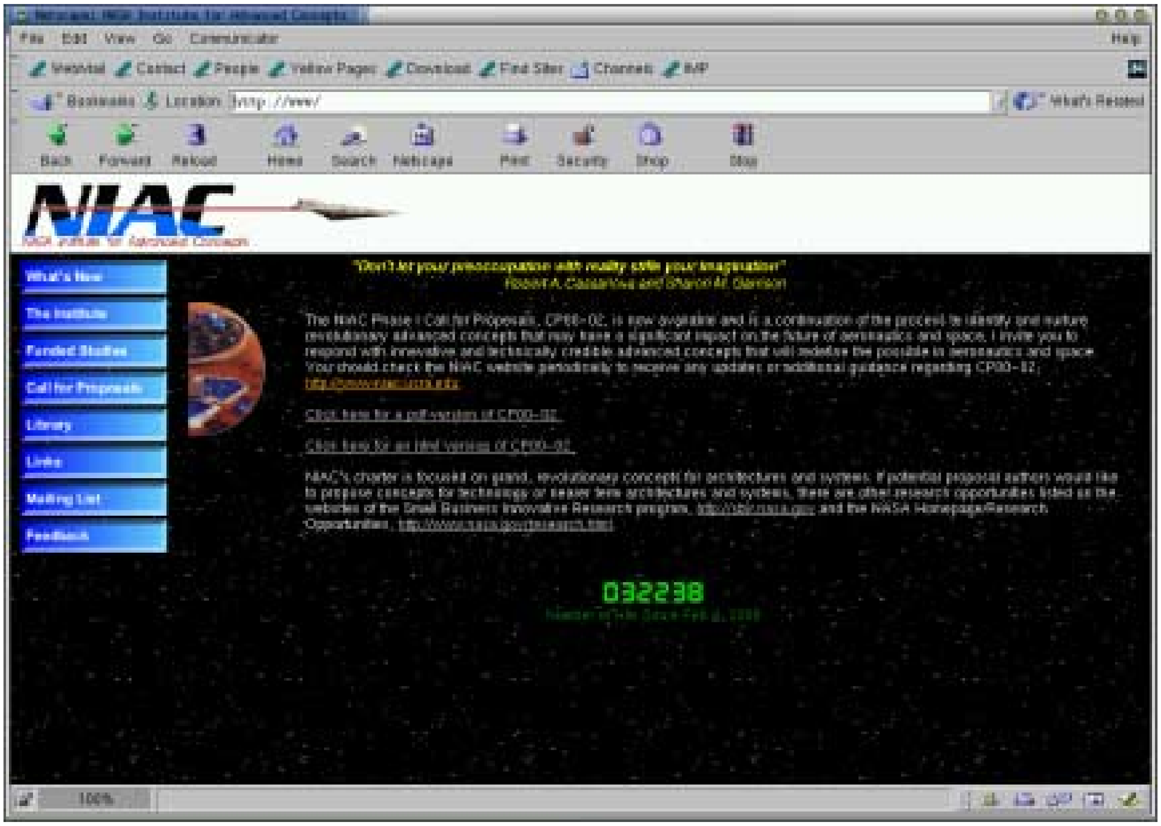
The servers use RedHat Linux for their operating systems, Apache for the web server, Sendmail for the email server, Sybase SQL Server for the database, and OpenSSL for web and email security. The workstations use Windows 2000 for their operating systems, Microsoft Office 2000 Professional for office applications, Netscape Communicator for email access, and Adobe Acrobat for distributed documents.

Virtual Institute

NIAC envisions progressive use of the Internet as a key element in its operation. The Internet is the primary vehicle to link the NIAC office with grantees, NASA points of contact, and other members of the science and engineering community. The Internet will be the primary communication link for publicizing NIAC, announcing the availability of Calls for Proposals, receiving proposals and reporting on technical status. All proposals submitted to NIAC must be in electronic format. All monthly reports from the grantees to NIAC and from NIAC to NASA are submitted electronically. The peer review of proposals is also conducted electronically whenever the peer reviewer has the necessary Internet connectivity and application software.

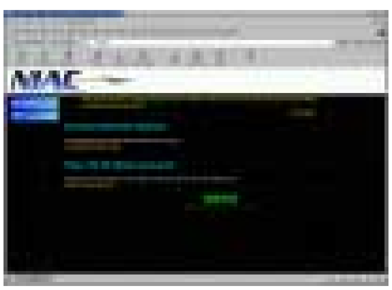
ANSER created and maintains the NIAC website at http://www.niac.usra.edu, which serves as the focal point of NIAC to the outside world. The website can be accessed to retrieve and submit NIAC information and proposals. The NIAC website is linked from the NASA Technology Integration Division (NTID) website at http://ntpio.nasa.gov as well as the NASA Research Opportunities website at http://www.nasa.gov/research.html, the Office of Earth Science Research Opportunities at http://www.earth.nasa.gov/nra/current/index.html and the Small Business Innovative Research program, http://sbir.nasa.gov. Numerous other links to the NIAC website are now established from NASA Centers and science and engineering websites. The visibility of NIAC has improved to the point that their website has been receiving almost 90 hits per day. Between January 31, 2000, and February 1, 2001 the NIAC website has logged 18,880 connections. Figure 8 depicts the site map of the NIAC website.

Figure 8. Site Map of the NIAC Website, http://www.niac.usra.edu.



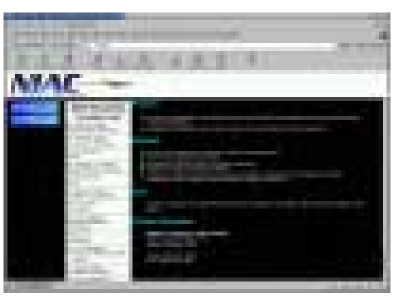
The NIAC web page has undergone a marked change since last year's Annual Report. The implementation of Java Server Pages has allowed the dynamic production of certain web pages. This is most evident in the *Funded Studies* section and the *Mailing List* section."

The number of hits by Internet users has increased to approximately ninety per day, confirming that NIAC has continued to grow in popularity.



What's New

What's New contains news about NIAC. There is also a link to the latest Commerce Business Daily release pertaining to NIAC.

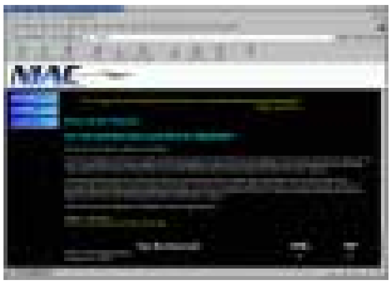


The Institute

The Institute contains information about NIAC including a list of the NIAC Science, Exploration and Technology Council members, Purpose, Method, Goal, and Contact information. There is a link to an organizational chart of NIAC, also.

Funded Studies

Funded Studies provides information about each Principal Investigator and project that NIAC has funded. There are links to various documents including an abstract of each of the proposals, presentations and Final Reports.

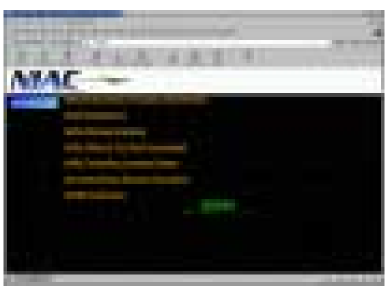


Call for Proposals

Call for Proposals is a link to the current Call for Proposals. There is a link to the Questions & Answers section provided also.

Library

The *library* contains an archive of previous Calls for Proposals, NIAC Annual Reports and other miscellaneous documents. There are links to view the proceedings of Fellows meetings and various workshops in this section as well.



Links

Links to other sites are provided in this section.

Mailing List

NIAC provides a *mailing list* where people can receive the latest Call for Proposals via Email. An individual is allowed the capability to add, edit and/or delete his/her own entry in this section.

Feedback

Feedback provides users the opportunity to ask questions about NIAC. Questions and answers pertaining to the current Call for Proposals may be viewed in this section.

Communication and Outreach to the Science and Engineering Community

In addition to the continuous, open communication provided through the NIAC website, NIAC uses a variety of methods to provide information to NASA and the research community and to receive feedback. Active and aggressive coordination with NASA HQ and the Centers is an important element in maintaining the flow of feedback to NIAC concerning the eventual infusion of NIAC-developed concepts back to NASA programs. Likewise, open exchange of information with the science and engineering community is critical to creating the atmosphere to inspire revolutionary concepts and to provide an open review of funded concepts by peers.

ADVANCED CONCEPT SELECTION PROCESS

Publicity

Publicity regarding the availability of a NIAC Phase I Call for Proposals is provided to the community through:

- Publication of an announcement in the *Commerce Business Daily*
- Notices sent to a NIAC email distribution list generated from responses by persons who signed up on the NIAC web site to receive the Call
- Announcements on professional society web sites or newsletters (American Institute for Aeronautics and Astronautics, American Astronautical Society and the American Astronomical Society)
- Announcements on the USRA and NIAC web sites
- NASA GSFC News Release
- Web links from NASA Enterprise web pages
- Web link from the NASA Coordinator's web page
- Announcements to a distribution list for Historical Black Colleges & Universities, Minority Institutions and Small Disadvantaged Businesses provided by NASA
- Distribution of announcements to an Earth Sciences list provided by NASA GSFC
- Announcements distributed at technical society meetings

Since Phase II awards are based on a down select from Phase I winners, all Phase II Call for Proposals are emailed directly to past Phase I winners who have not previously received a Phase II contract.

Solicitation

The actual solicitation for advanced concepts is assembled and published by the NIAC staff. Since the technical scope of the solicitation is as broad as the NASA Mission, the solicitation wording emphasizes the desire for revolutionary advanced concepts that address all elements of the NASA Mission. This is particularly true for Phase I solicitations.

The scope of work is written to inspire proposals in all NASA Mission areas and contains brief descriptions of NASA Enterprise areas of emphases. In general, proposed advanced concepts should be:

- Revolutionary, new and not duplicative of previously studied concepts
- An architecture or system
- Described in a mission context
- Adequately substantiated with a description of the scientific principles that form the basis for the concept
- Largely independent of existing technology or unique combination of systems and technologies

The evaluation criteria are structured to convey what is being sought and are summarized in Figure 9.

PHASE I ***6 months*** **$50 - $75K**	**PHASE II** ***Up to 24 months*** **Up to $500K**
• Is the concept revolutionary rather than evolutionary? To what extent does the proposed activity suggest and explore creative and original concepts? • Is the concept for an architecture or system, and have the benefits been qualified in the context of a future NASA mission? • Is the concept substantiated with a description of applicable scientific and technical disciplines necessary for development?	• Does the proposal continue the development of a revolutionary architecture or system in the context of a future NASA mission? Is the proposed work likely to provide a sound basis for NASA to consider the concept for a future mission or program? • Is the concept substantiated with a description of applicable scientific and technical disciplines necessary for development? • Have enabling technologies been identified, and has a pathway for development of a technology roadmap been adequately described? • Has the pathway for development of a cost of the concept been adequately described, and are costing assumptions realistic? Have potential performance and cost benefits been quantified?

Figure 9. NIAC Proposal Evaluation Criteria

A NIAC Call for Proposal is distributed in electronic form only. At the present time, solicitation for one Phase I and one Phase II is prepared and released every calendar year. These releases occur generally in the latter half of the calendar year.

Proposals

All proposals must be submitted electronically to the NIAC in **.pdf** format in order to be considered for award. Technical proposals in response to Phase I Call for Proposals are limited to 12 pages. Phase II technical proposals are limited to 25 pages. Cost proposals have no page limit.

Phase II proposals are only accepted from authors who have previously received a Phase I award and have not previously received a Phase II follow-on contract. The due date is the same for the Phase II proposal and the associated Phase I final report. Phase I Fellows may submit a Phase II at any time after completion of their Phase I grant, but it must be received by NIAC by the designated due date in order to be considered in a particular review cycle.

Peer Review

NIAC peer reviewers represent a cross-section of senior research executives in private industry, senior research faculty in universities, specialized researchers in both industry and universities, and aerospace consultants.

Each reviewer is required to sign a non-disclosure and no-conflict-of-interest agreement prior to their involvement. A small monetary compensation is offered to each reviewer. The technical proposals and all required forms are transmitted to the reviewer over the Internet, by diskette or by paper copy, depending on the electronic capabilities of each reviewer. Reviewers are given approximately thirty days to review the technical proposals and return their completed evaluation forms.

Each proposal receives at least three independent peer reviews. Each reviewer evaluates a proposal according to the criterion stated in the Call for Proposals. Templates/forms are created to help guide the reviewer through the process of assigning a numerical ranking and providing written comments.
Only NIAC and USRA staff analyze cost proposals.

The ANSER Corporation provided valuable assistance to the peer review process through a search of its archives, knowledge bases and additional resources. These information databases were used to provide additional background on prior and ongoing advanced concept research efforts sponsored by NASA and non-NASA sources. To help assure that a proposed concept is not duplicating previous studied concepts, NIAC accesses the NASA Technology Inventory Database and searches for related NASA funded projects.

Results of the peer reviews are compiled by NIAC, rank-ordered by a review panel and prepared for presentation to NASA in a concurrence briefing.

NASA Concurrence

The NIAC Director is required to present the apparent research selections to the NASA Chief Technologist and representatives of the NASA Strategic Enterprises before the announcement of awards. Technical concurrence by NASA, required before any subgrants or subcontracts are announced or awarded, is obtained to assure consistency with NASA's Charter and that the concept is not duplicating concepts previously, or currently being, developed by NASA.

Awards

Based on the results of the NIAC peer review, technical concurrence from NASA's Office of the Chief Technologist and the availability of funding, the award decision is made by the NIAC Director. All proposal authors are notified electronically of the acceptance or rejection of their proposal. If requested, feedback based on the peer review evaluator's comments is provided to the non-selected proposers.

The USRA contracts office then begins processing contractual instruments to each of the winning organizations. Also, the NIAC staff inputs all the pertinent technical information regarding the winning proposals into the NASA Technology Inventory Database, as well as the NIAC website.

The "product" of each award is a final report. All final reports are posted on the NIAC website for public viewing.

CONTRACT MANAGEMENT

With each new advanced concept award, contract management increases not only in importance but also in the time devoted to it by the NIAC. The major contract management tools used by NIAC are monthly reports and site visits.

Reports

Monthly reports are used by NIAC to monitor technical and management progress of each selected program. They are contractually required in both Phase I and Phase II subgrants and subcontracts. These reports are for the exclusive management use of NIAC and are not publicly disseminated.

Final reports in .pdf electronic format are required within 30 days of completion of the subgrant or subcontract and are posted on the NIAC website within a few days of receipt.

Phase II contractors are required to submit an interim report during the 12th month of the first year of their contract.

Site Visits

Phase II contracts are structured with a one-year contract plus an option for the remaining performance period. Each Phase II contractor is required to host a site visit by the NIAC Director and other technical experts during the 9th or 10th month of the first year of their contract. Site visits are used to measure program progress on a first-hand basis for Phase II awards. These visits are a particularly valuable management tool to the NIAC Director in determining the overall status and operating environment of a particular program at a given point in time. Site visits are conducted by the NIAC Director who will be accompanied by experts in related technical fields and by NASA representatives who may want to consider follow-on funding directly from NASA. Site visits are scheduled prior to the exercise of any subcontract option.

PLANS FOR THE FOURTH YEAR AND BEYOND

During the next two years of the NASA contract, NIAC will build on the operational framework established in the first three years to broaden the constituency of innovators responding to NIAC initiatives and to expand the participation of scientists and engineers from outside of the normal aerospace disciplines. NIAC will continue to improve the Phase I/Phase II selection strategy to inspire and competitively select revolutionary advanced concepts with the greatest potential for significant impact. To reinforce an atmosphere of revolutionary and innovative, but technically credible thinking, the technical themes chosen for annual meetings and workshops will give special emphasis to scientific discoveries and emerging technologies that could be the bases for innovative, interdisciplinary architectures and systems aimed at the major challenges of aeronautics and space.

The activities planned for the fourth and fifth years will build on NIAC's leadership position to inspire, select and fund revolutionary advanced concepts and to orchestrate the transition of successful concepts into consideration by NASA for long range development. Figure 10 summarizes the major activities planned for the fourth and fifth contract years.

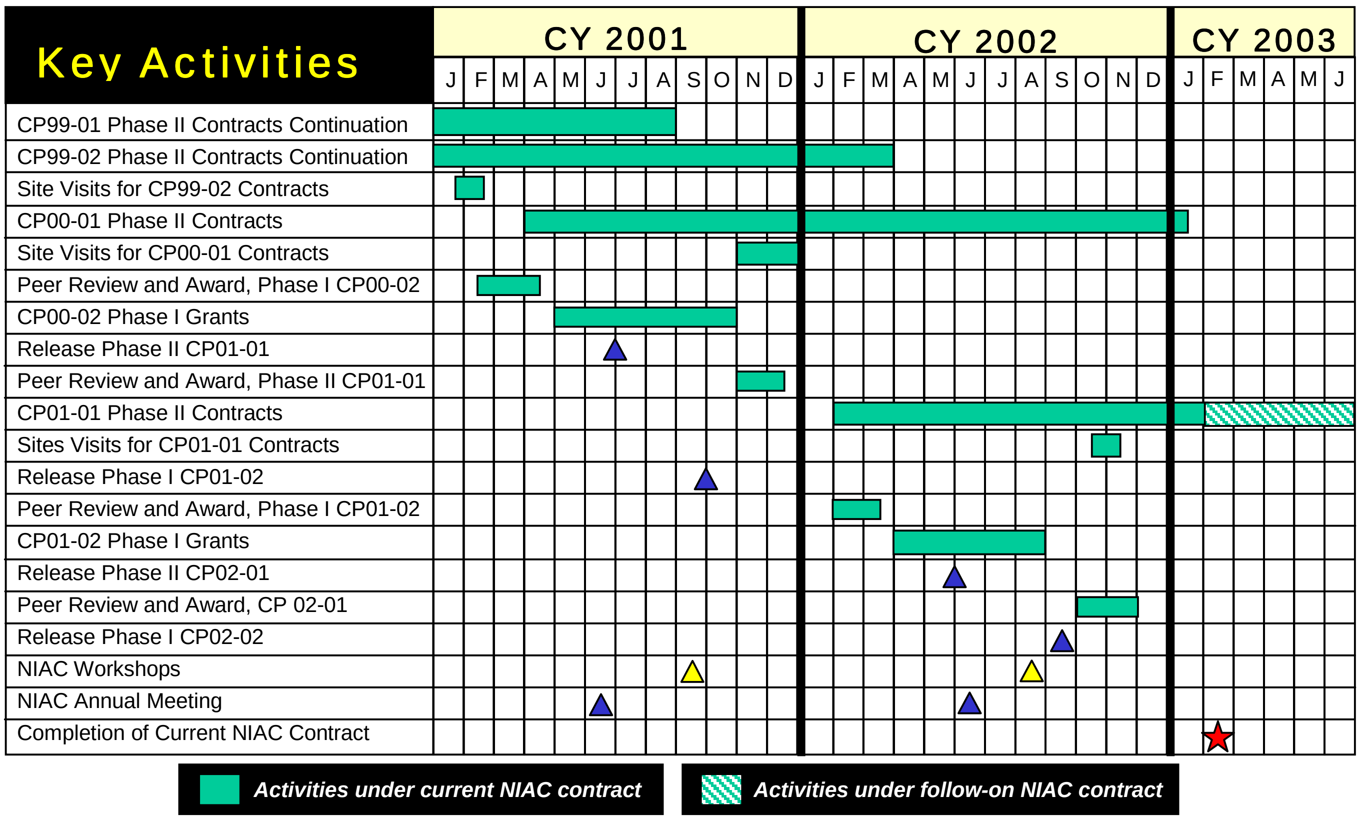


Figure 10. Key Activities during the Third Contract Year

Advanced Concept Solicitation, Selection and Award

The peer review, selection, concurrence by NASA and award based on proposals received in response to Phase II Call CP 00-01 and Phase I Call CP 00-02 will be completed in the first quarter of the fourth contract year. Grant and contract start dates are anticipated in March and May 2001, respectively.

The next Phase II Call for Proposals, CP 01-01, will be sent to the PIs selected for CP 00-02 within the first two months of their Phase I grant. Phase II proposals received for CP 01-01 will be peer reviewed and awarded in 2002. The next Phase I Call for Proposals, CP 01-02 will be released Fall 2001 and the peer review and award will occur in 2002. Additional releases of Phase I and Phase II Calls will follow in 2002 based on the assumption of a follow-on contract to continue the NIAC operation. No awards will be made that would extend past the current NIAC contract performance period, ending February 9, 2003.

Publication of the Calls and distribution of general information about the NIAC will be achieved over the NIAC website. Direct web links from technical societies and NASA web pages will continue as the method to notify the community about NIAC. In addition, the NIAC distribution list and distribution lists provided by NASA will be used to notify interested persons about NIAC research opportunities.

Management of Awards

NIAC will continue to require all grant and contract recipients to submit monthly and final reports. In addition, all Phase II contractors will be required to submit an annual report at the completion of their first year of funded activity.

All Phase II contractors will be required to host a site visit and to submit an annual report before the end of their first contract year. Site visits are tentatively scheduled during January and February 2001 for the CP 99-02 awards, and during November 2001 for the CP 00-01 awards. Participants in the site visits will include the NIAC Director, experts in the technical field of the concept, and NASA representatives key to the eventual transition to long range NASA funding.

Communication with NASA, Other Federal Agencies and the Research Community

Since NIAC is a virtual institute, NIAC's principle method of communication with the technical community will be through the NIAC website. In addition, NIAC will utilize the NASA Technology Inventory Database to distribute information about NIAC projects.

In addition to contractually required reports to NASA, the NIAC Director will sustain a flow of information to the technical and management levels of NASA. These activities will encompass appropriate status reports and overviews plus technical meetings in specialized technical areas. In general, the visits to the NASA Centers and JPL will include meetings with the Center Director, top management staff and technical groups related to current and future NIAC areas of emphasis. Visits to NASA HQ will be with Associate Administrators, Enterprise Representatives, Technical Theme Managers, the Chief Technologist and the Chief Scientist.

The third NIAC Annual Meeting is scheduled for June 5-6, 2001 at NASA Ames Research Center, and will showcase the current grants and contracts. One or more focused workshops may be conducted during the late summer and early Fall 2001 and 2002, if it is felt that the workshop would result in additional new and innovative proposals in response to the next Phase I Call.

Oversight by USRA Management

The NIAC Science, Exploration and Technology Council will meet to receive an overview of the status and plans of NIAC on the day following each of the scheduled annual meetings and the workshops. The Council will issue a report to USRA management and NASA on NIAC's operation and will offer suggestions for future activities.

APPENDIX

Descriptions of the Phase II Awards during the first three years of operation

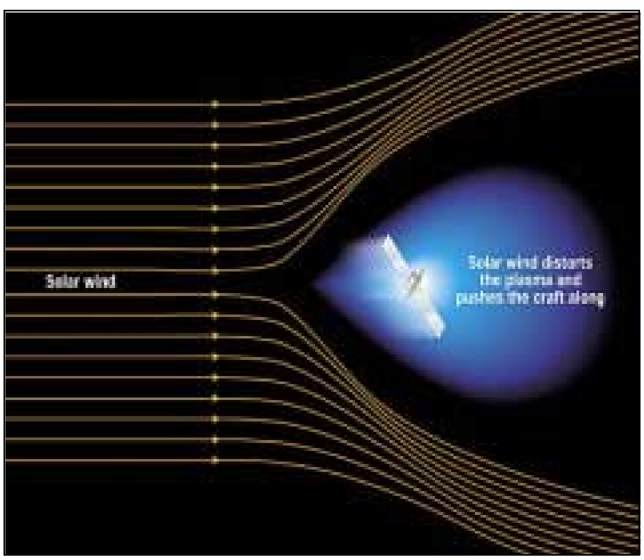
Call for Proposals 99-01
Abstracts and Graphics

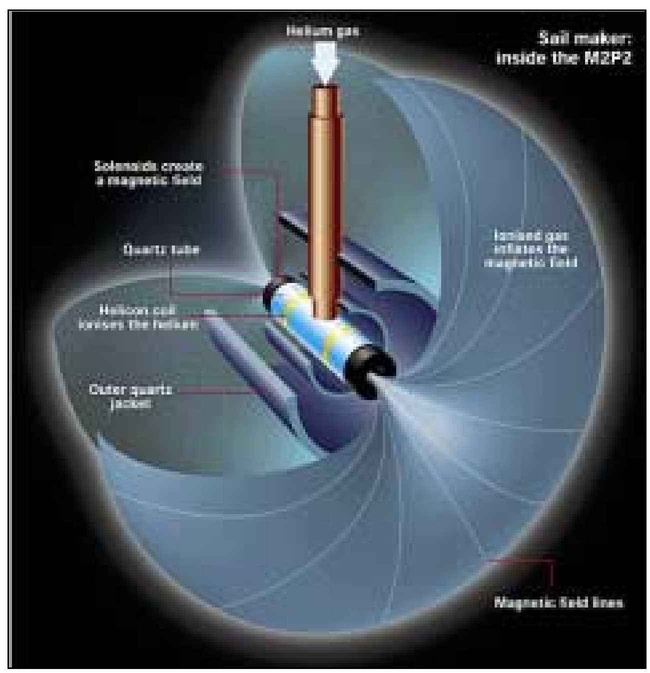
Mini-Magnetospheric Plasma Propulsion

ROBERT M. WINGLEE
University of Washington

The Mini-Magnetospheric Plasma Propulsion, M^2P^2, system provides a revolutionary means for spacecraft propulsion that can efficiently utilize the energy from space plasmas to accelerate payloads to much higher speeds than can be attained by present chemical oxidizing propulsion systems. The system utilizes an innovative configuration of existing technology based on well-established principles of plasma physics. It has the potential of feasibly providing cheap, fast propulsion that could power Interstellar Probe, as well as powering payloads that would be required for a manned mission to Mars. As such, the proposed work is for missions out of the solar system and between the planets.

The project is interdisciplinary involving space science, plasma engineering and aeronautics and space transportation, which are key components of NIAC's program. The M^2P^2 system utilizes low energy plasma to transport or inflate a magnetic field beyond the typical scale lengths that can be supported by a standard solenoid magnetic field coil. In space, the inflated magnetic field can be used to reflect high-speed (400 – 1000 km/s) solar wind particles and attain unprecedented acceleration for power input of only a few kW, which can be easily achieved by solar electric units. Our initial estimates for a minimum system can provide a typical thrust of about 3 Newton continuous (0.6 MW continuous power), with a specific impulse of 10^4 to 10^5 s) to produce an increase in speed of about 30 km/s in a period of 3 months. Proposed optimization could allow the development of a system that increases the acceleration with less expenditure of fuel so that a mission that could leave the solar system could become a reality.





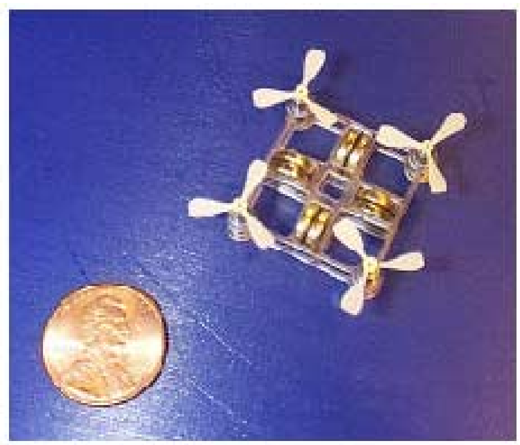
Mesicopter: A Meso-Scale Flight Vehicle

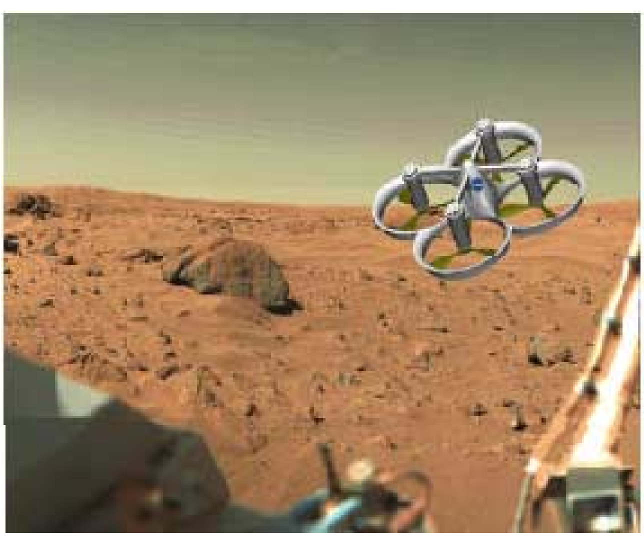
ILAN KROO

Stanford University

A team of researchers from Stanford University, SRI, and M-DOT Corporation propose to build the 'mesicopter', a centimeter-size electric helicopter, designed to stay airborne while carrying its own power supply. This device represents a revolutionary class of flight vehicles at an unprecedented size, and suggests a range of potential uses. The proposed work focuses on the development of mesicopters for atmospheric science, permitting in-situ measurements of meteorological phenomena such as downbursts and wind shear, and with unique capabilities for planetary atmospheric studies. Swarms of mesicopters could provide atmospheric scientists with information not obtainable using current techniques and could aid in the understanding of phenomena that play a critical role in aviation safety.

Better characterization of atmospheric phenomena on Mars and other simple sensing tasks may be feasible with these very low mass and low cost aerial micro-robots. The mesicopter will pioneer the application of new aerodynamic design concepts and novel fabrication techniques, including solid free-form fabrication and VLSI processing steps. These techniques may ultimately allow the mesicopter to be scaled down to millimeter dimensions. Significant challenges are anticipated in the areas of materials, battery technology, aerodynamics, control and testing. This proposal describes work for the first phase of the program in which initial designs and fabrication tests are used to evaluate the concept's feasibility. An outline of subsequent phases is also provided.





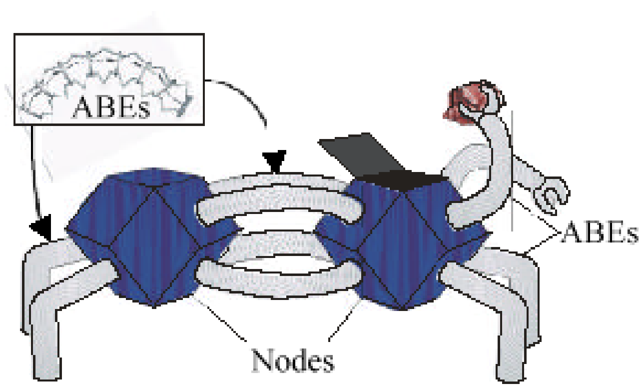
Self-Transforming Robotic Planetary Explorers

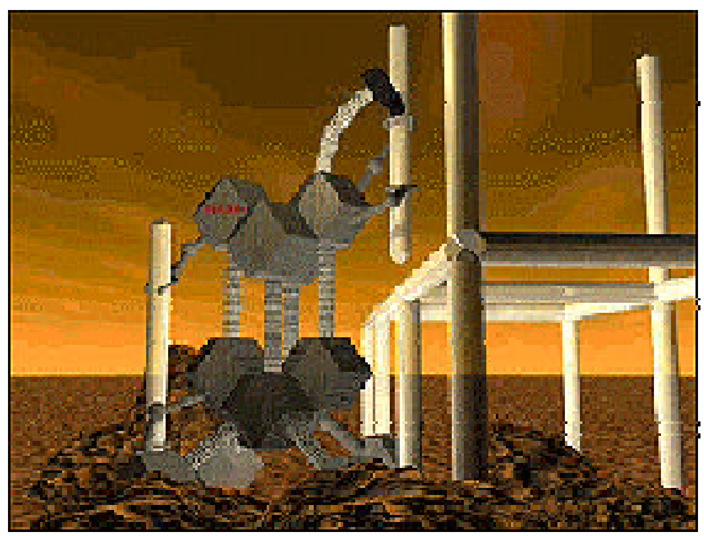
STEVEN DUBOWSKY
Massachusetts Institute of Technology

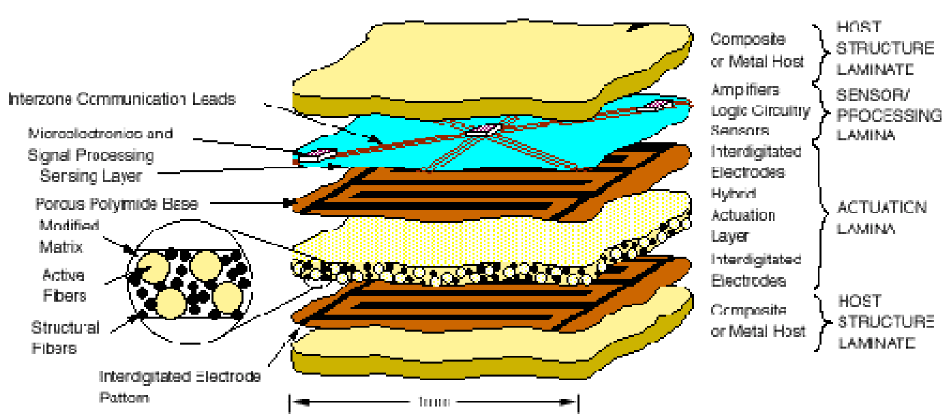
While the 1997 Sojourner mission was an outstanding technical feat, future robotic exploration systems will need to be far more capable. They will need to explore challenging planetary terrain, such as on Mars, with very limited human direction. To achieve this capability, major revolutionary breakthroughs in planetary robotic technology will be required. Here a new and potentially very important concept for robotic explorers is proposed. These are self-transforming planetary explorers – systems that are able to autonomously change their physical and software structure to meet the challenges of its environment and task. Such systems could dramatically enhance the ability of planetary explorers to survive and to successfully complete their mission objectives.

In the concept, the robotic systems would be constructed with reconfigurable elements, or modules. Based on sensor information and onboard models and analysis, the system would autonomously transform itself into the "best" configuration to meet the local challenges.

System configurations that could be self-constructed from the original basic system are called cognates. Realizing effective and practical self-transforming systems is difficult for a number of reasons. During this Phase I program, the feasibility of the concept will be studied. While the challenges associated with this study are substantial, so are the potential benefits. If the self-transformation concept can be practically applied, it could significantly impact future planetary exploration missions in the year 2010 and beyond.



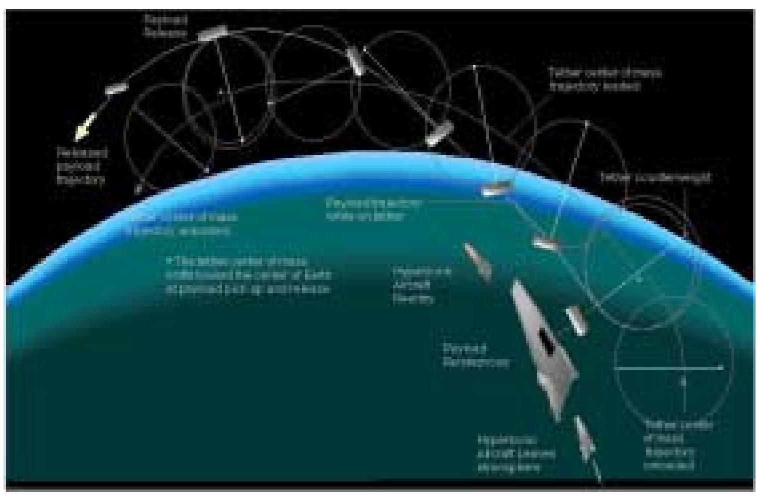


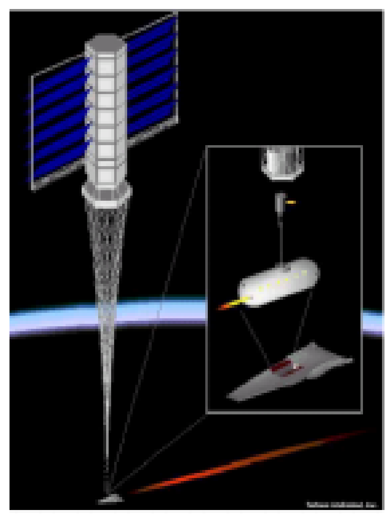


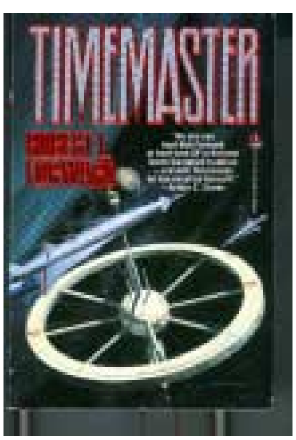
Moon and Mars Orbiting Spinning Tether Transport (MMOSTT)

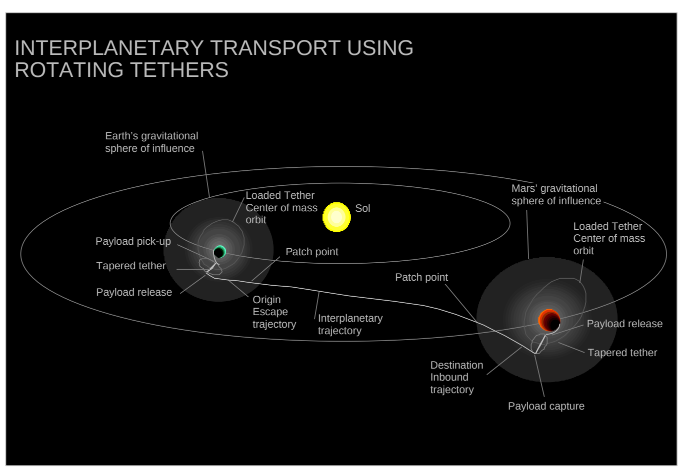
ROBERT P. HOYT
Tethers Unlimited, Inc.

Systems of rotating momentum-exchange tether facilities can repeatedly transport payloads between low Earth orbit, geostationary orbit, the Moon, and Mars with minimal propellant expenditure. The Phase I effort developed a design for a Cislunar Tether Transport System that uses one tether in elliptical, equatorial Earth orbit and one tether in low lunar orbit. Numerical modeling verified that this system could provide round-trip travel between LEO and the surface of the Moon with near-zero propellant requirements. Using currently available tether materials, such a system would require a total mass of less than 28 times the mass of the payloads it can handle. Because a rocket-based system would require a propellant mass of at least 16 times the payload mass to perform the same job, the fully-reusable tether system would be competitive from a perspective after only two trips, and would provide large cost savings for frequent round-trip travel. The Phase I effort also developed a conceptual design for a tether system for rapid Earth-Mars travels. In the Phase II effort, we will combine and improve these system designs to develop a tether transportation architecture that can combine and improve these system designs to develop a tether transportation architecture that can provide low-cost transport to the Moon, Mars, and elsewhere in the solar system. In order to determine specific requirements for the hardware and technologies needed for tether transport systems, we will investigate concepts for enabling payload capsules to rende3zvous with rotating tether systems, we will investigate concepts for enabling payload capsules to rendezvous with rotating tether facilities, and develop methods to minimize propellant requirements and maximize rendezvous windows. We will then develop a detailed design for a low-cost flight experiment to begin demonstrating the momentum-exchange tether technologies needed to create tether transport systems.





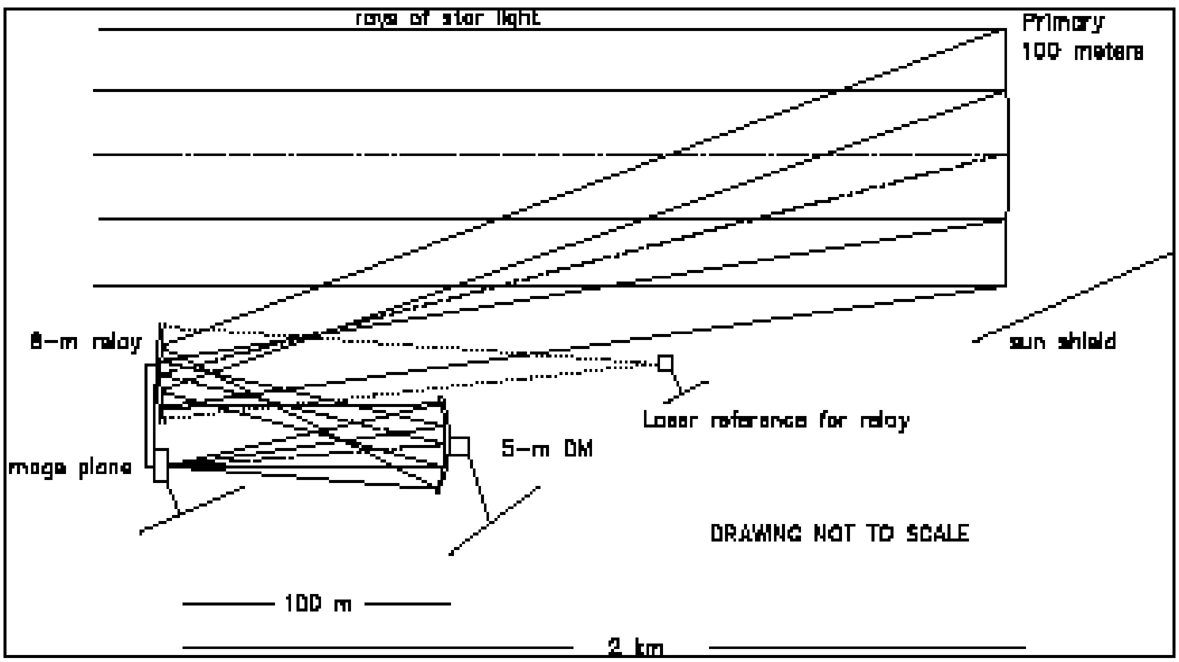




Very Large Optics for the Study of Extrasolar Terrestrial Planets

NEVILLE J. WOOLF
University of Arizona, Steward Observatory

To evaluate habitability and to research for primitive life on Earth-like planets of other stars, telescopes in space with collecting areas of 10 m 2 to 1,000k000 m 2 are needed. We propose to study revolutionary solutions for reflecting telescope in this size range, going beyond technologies we are developing for adaptive secondary mirrors and for ultra-lightweight panels for the NGST. Ways will be explored to build very large lightweight mirrors and to correct their surface errors. As a specific example, we will study a 100 m reflector with a concave NGST-size secondary relay that images the primary onto a 5-m deformable tertiary. The primary, free-flying 2 km from the secondary would be assembled from 5-m flat segments made as reflecting membranes stretched across triangular frames. A 1/20 scale (5 m) image of the primary is formed on the deformable mirror, itself segmented, where panel deformation would be corrected. Scalloping of the segments would compensate the missing curvature of primary segments.



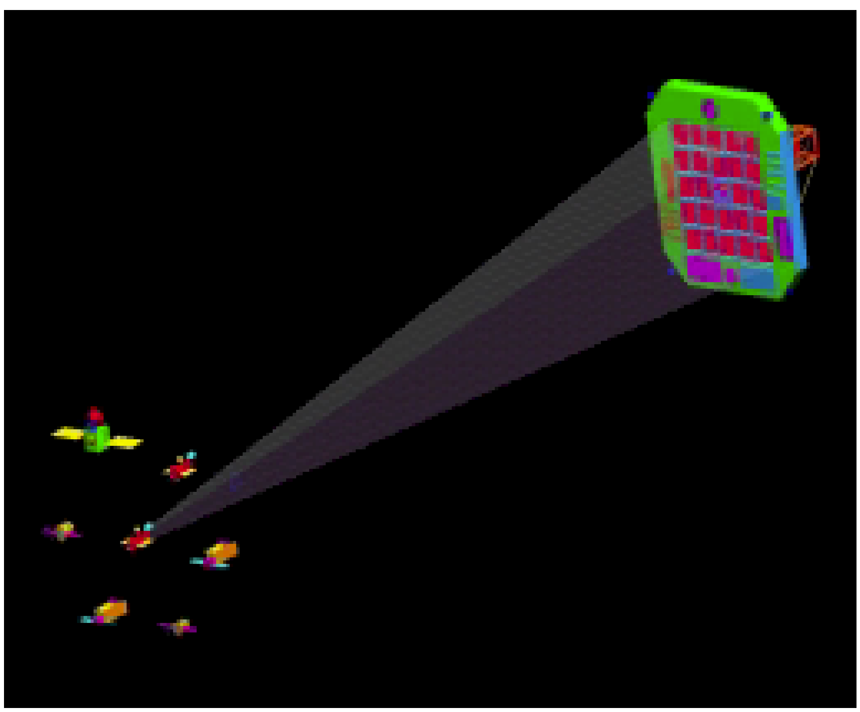
An Ultra-High Throughput X-Ray Astronomy Observatory with A New Mission Architecture

PAUL GORENSTEIN

Smithsonian Institution, Astrophysical Observatory

We propose a study of new mission architecture for an ultra high throughput x-ray astronomy observatory containing a 10 m aperture telescope and a set of detectors. It has potentially much better ratios of effective area to weight and cost than current approaches for the 1 m class AXAF, XMM and "next generation" 3 m class observatories. Instead of a single spacecraft that contains the telescope, the optical bench, and a fixed limited set of detectors in the new architecture, the telescope and an unlimited number of detectors are all on separate spacecraft. Their trajectories are in the same vicinity either in high Earth orbit or the L2 point. Usually, only one of the detectors is active. The active detector places and maintains itself at the telescope's focus by station keeping. Its distance and aspect sensors provide signals that drive electric propulsion engines on the detector spacecraft, which regulate its distance from the telescope to be precisely equal to the focal length.

Unlike current systems, detectors can be replaced and new ones added by launching a small spacecraft that will rendezvous with the others. To reduce its mass, the telescope has a segmented architecture and the segments are actively aligned. The study will identify the nature and magnitude of problems that need to be solved in order to develop a 10 m class X-ray astronomy observatory with these new architectures. The study will involve both analysis and laboratory measurements. The mission architecture is applicable to other observatories.



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Advanced System Concept for Total ISRU-Based Propulsion and Power Systems for Unmanned and Manned Mars Exploration

ERIC E. RICE

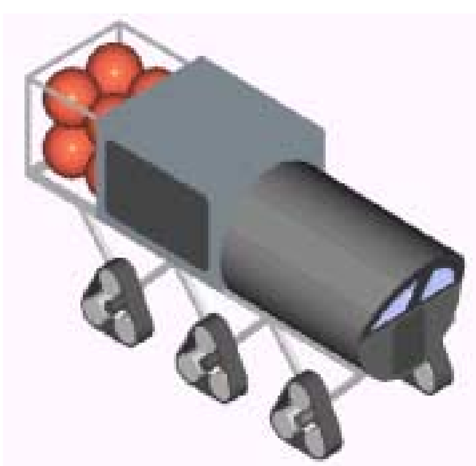
Orbital Technologies Corporation (ORBITEC)

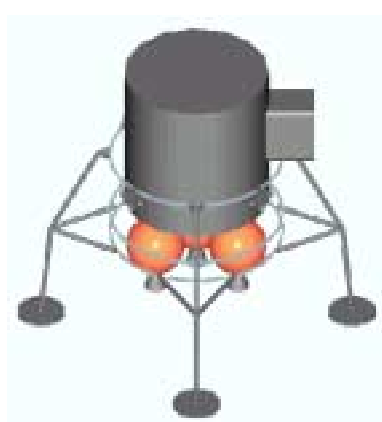
ORBITEC proposes to conceptualize cost-beneficial Mars ISRU-based systems and an overall architecture for producing and utilizing optimized Mars-based ISRU propellant combinations that are derived from the atmosphere to support ground and flight transportation and power systems. For ground systems, we include: automated unmanned roving vehicles, personal vehicles, two-person unpressurized rovers, manned pressurized transport rovers and larger cargo transports. For flight systems, we include: Mars sample return vehicles, unmanned and manned surface-to-surface "ballistic hoppers," surface-to-orbit vehicles, interplanetary transport vehicles, powered balloons, winged aerocraft, single-person rocket backpacks, and single-person rocket platforms. Auxiliary power systems include: Brayton cycle turbines and fuel cells for small Mars outposts.

In Phase I, we accomplished a preliminary systems study which provided the approach needed to ultimately assess the benefits of our ISRU proposed architecture. For the cost-effective human exploration of Mars, we will need to use in-situ resources that are available on Mars, such as: energy (solar); gases or liquids for life support, ground transportation, and flight to and from other surface locations, orbit and Earth; and materials for shielding, habitats and infrastructure. Probably the most cost-effective and easiest use of Martian resources is the atmosphere (95.5% CO_2). CO_2 can be easily processed and converted to carbon monoxide or carbon and oxygen propellants (SCO/LOX, C/LOX) and with hydrogen, either Earth-supplied or also derived from the Mars atmosphere (via H_2O) or Mars soil, many more ISRU propellant options become available, including: C_2H_2/LOX, C_2H_4/LOX, CH_3OH/LOX, CH_4/LOX, C_3Hg/LOX, LH_2/SOX, LH_2/LOX, CH_3OH/H_2O_2, etc. With small amounts of N_2 also in the atmosphere (2.7%), propellant ingredients such as N_2O, N_2O_4, N_2H_4, MMH, UDMH are possible.

ORBITEC proposes to conduct the necessary advanced concept analysis that will provide the knowledge base required to eventually select the resources and systems that are the most effective in keeping space exploration costs low. In this study, we will focus on the innovative and revolutionary use of solid CO, C and C_2H_2 as fuels in hybrid rocket propulsion and power system applications. However, we plan to evaluate all reasonable potential ISRU propellant options and develop "families" of propellants that are optimally used in the overall transportation and chemical energy storage systems. New advanced cryogenic hybrid rocket propulsion systems are also proposed that will tremendously improve the performance of CO/O_2, C/O_2, or C_2H_2/O_2 propulsion (as well as others, e.g., CH_4/LOX) such that these could be the best options for transportation and power needs. The implementation of this architecture is expected to greatly support logistics and base operations by providing a reliable and simple way to store solar or nuclear generated energy in the form of chemical energy that can be used for ground transportation and power generators. ORBITEC has proven that the CO/O_2 propulsion concept is technically feasible by conducting test firings of a small-scale solid CO/O_2 hybrid!

In this Phase II effort, ORBITEC proposes to completely develop a long-term Mars ISRU-based propellant architecture that is optimized to keep Mars exploration and colonization costs to a minimum. We propose to conduct some straightforward rocket engine tests in our current hardware with SC/O_2 and SC_2H_2/O_2 to determine the feasibility of these higher performing propellant combinations. We expect that our analysis shall show significant cost-benefit for ISRU propellants and that we shall be able to confidently recommend the top groups or families of propellant combinations that can satisfy the across-the-board transportation and auxiliary power needs of our Mars exploration/colonization activities of the 21st century. This information should then allow the right emphasis on technology and system development





Global Constellation of Stratospheric Scientific Platforms

KERRY T. NOCK
Global Aerospace Corporation

Global Aerospace Corporation (GAC) is developing a revolutionary and cross-cutting concept for a global constellation of hundreds of stratospheric super-pressure balloons which can address major scientific questions relating to NASA's Earth Science Mission by measuring stratospheric gases, collecting data on atmospheric circulation, observing the Earth's surface, and detecting and monitoring environmental hazards. Such a system could augment and complement satellite measurements and possibly replace satellites for making some environmental measurements.

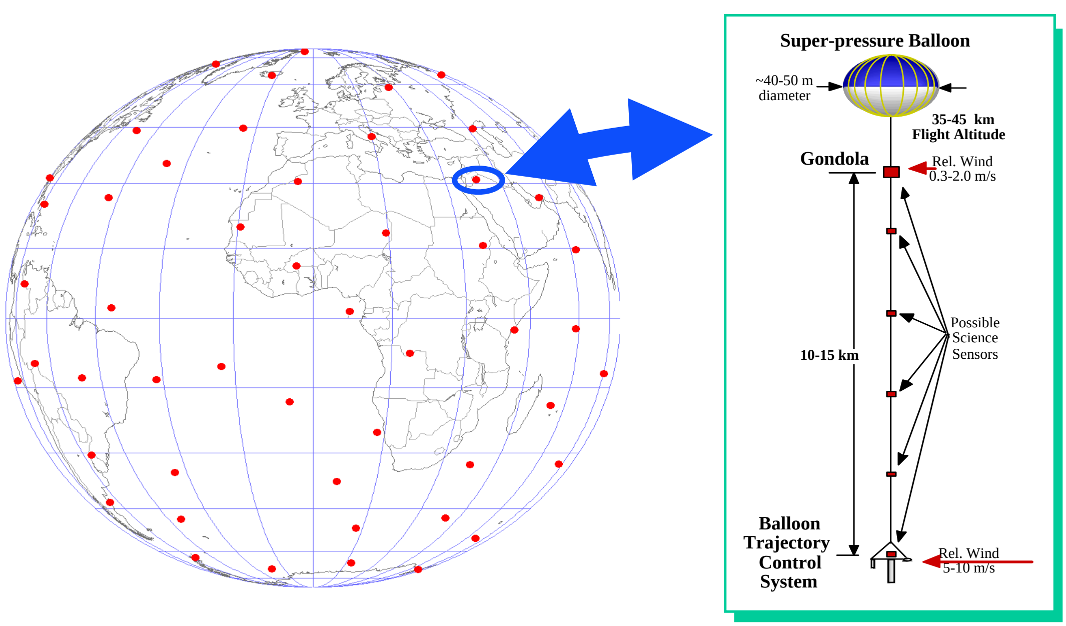
The technical and programmatic keys to this new concept are:

- Achievable constellation geometry management,
- Significant and cost-effective scientific applications,
- Affordable, long-duration balloon systems,
- International agreements on overflight,
- Balloon trajectory control capability, and
- A global communications infrastructure.

In the satellite era, there has been a shift away from making conventional *in situ* measurements of the global environment to remote sensing from Earth orbiting spacecraft. After forty years, there may be some reason to challenge this remote sensing paradigm with a new *in situ* strategy. In combination, (a) the advance of electronics, (b) the inherent difficulty of making some remote measurements from satellites, and (c) the interest in simultaneous global measurements, argue for a reevaluation of the current reliance on satellites for many global environmental measurements.

Total system cost for balloon constellations may be competitive with or lower than comparable spacecraft systems due to the inherent high cost of spacecraft and launch vehicles. A network of balloons will be less costly than a comparable network of spacecraft if the individual balloons have lifetimes measured on the order of years, thereby reducing the cost of replacement or refurbishment.

GAC is developing sophisticated geometry management strategies for global balloon constellations, exploring additional science applications and benefits, identifying technology needs and generating estimates of the cost of implementing such a revolutionary system.



A Realistic Interstellar Explorer

RALPH L. McNUTT, JR.

Johns Hopkins University, Applied Physics Lab

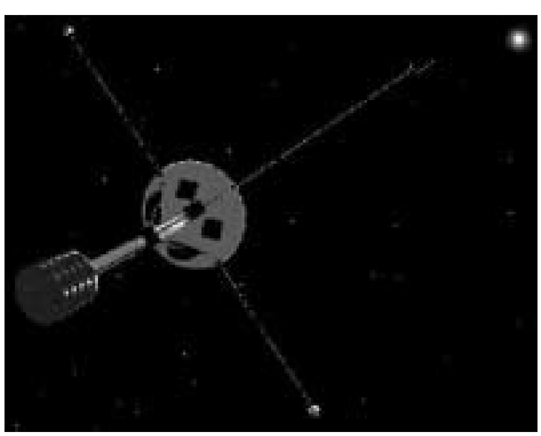
For more than 20 years, an "Interstellar Precursor Mission" has been discussed as a high priority for our understanding (1) the interstellar medium and its implications for the origin and evolution of matter in the Galaxy, (2) the structure of the heliosphere and its interaction with the interstellar environment, and (3) fundamental astrophysical processes that can be sampled *in situ*. The chief difficulty with actually carrying out such a mission is the need for reaching significant penetration into the interstellar medium (~1000 Astronomical Units (AU)[1]) within the working lifetime of the initiators (<50 years). During the last three years there has been renewed interest in actually sending a probe to another star system - a "grand challenge" for NASA – and the idea of a precursor mission has been renewed as a beginning step in a roadmap to achieve this goal [*Anderson*, 1999].

In the Phase I work, we have completed an initial scooping of the system requirements and have identified system drivers for actually implementing such a mission. The proposed Phase II work takes these drivers and the initial architecture concept and further defines them. In particular, industrial partners have been identified for some of these tasks and proof-of-principle breadboarding tasks and experiments have been defined for others. It is important to note that although we will be studying the full system architecture for the mission, much of the proposed effort is devoted to the development of the spacecraft architecture required for long-term cruise in deep space, and is so largely independent of the mission design and propulsion implementation used to provide high-speed escape from the Sun's gravity.

In the Phase I study we began the task of looking seriously at the spacecraft mechanical, propulsion, and thermal constraints involved in escaping the solar system at high speed by executing a ΔV maneuver of ~10 to 15 km/s in the thermal environment of ~4 R_S (from the center of the Sun) remains challenging. Two possible techniques we identified for achieving high thrust levels near the Sun are: (1) using solar heating of gas propellant, and (2) using a scaled-down Orion (nuclear external combustion) approach. We investigated architectures that combined with miniaturized avionics and miniaturized instruments, enable such a mission to be launched on a vehicle with characteristics not exceeding those of a Delta III.

We will examine a variety of propulsion means and their associated architectures including both solar flyby impulsive and low-thrust continuous concepts. We do not propose to consider any "breakthrough physics" propulsion schemes [*Millis*, 1999] as these are not in keeping with our self-imposed ground rules for considering "realistic" probe architectures.

We do propose to continue the cruise configuration architecture work [our NIAC Phase I Report and *McNutt et al*., 1999] with an emphasis on long-lived, self-healing architectures and redundancies that will extend the probe lifetime to well over a century. Such a long-lived probe could be queried at random over decades of otherwise hands-off operations. Finally, we will also look at the various systems trades for cruise architectures/propulsion system combinations. This systems approach for such an Interstellar Explorer has not been previously used to address all of these relevant engineering questions and will also lead to (1) a probe concept that can be implemented following a successful Solar Probe mission (concluding around 2010), and (2) system components and approaches for autonomous operation of other deep-space probes within the solar system during the 2010 to 2050 time frame.



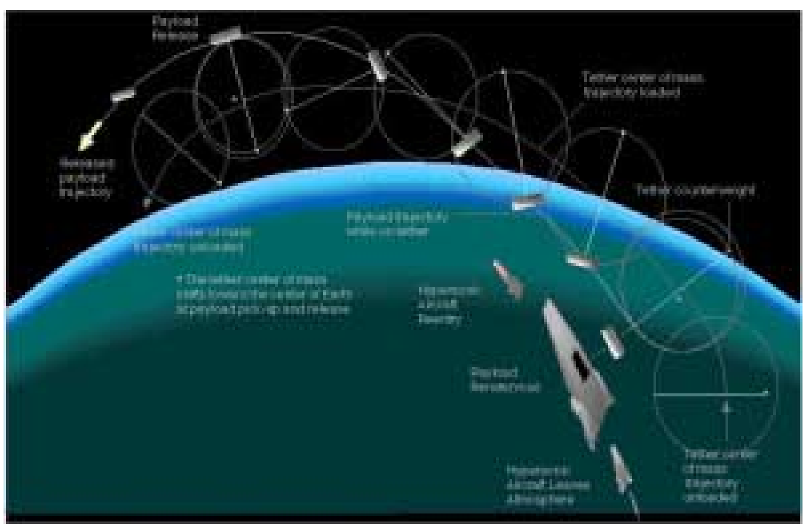
Hypersonic Airplane Space Tether Orbital Launch (HASTOL) Study

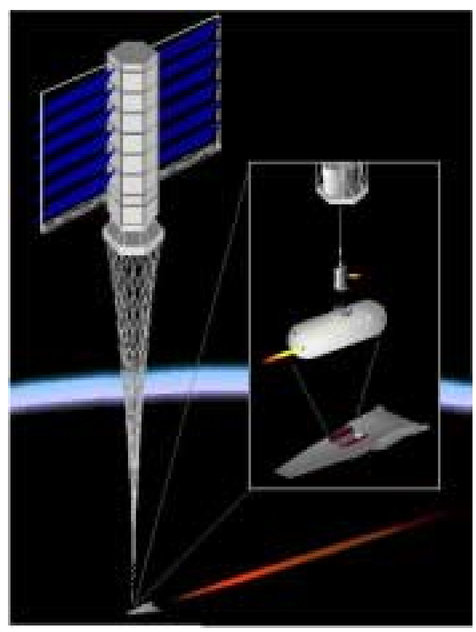
JOHN GRANT
The Boeing Corporation

The Hypersonic Airplane Space Tether Orbital Launch (HASTOL) concept combines the best features of fully reusable jet airplanes and space tethers to move payloads from Earth to space. The hypersonic airplane flies a 15-ton payload in a ballistic arc that reaches Mach 10 to 12 at an altitude of 100 km. The airplane is met by a homing grapple at the end of a rotating 600-km-long tapered tether in a 700-km orbit. The grapple couples to the payload, and the tether rotation lifts the payload into space at a mild 2.5 g's.

In Phase I, Boeing and Tethers Unlimited, Inc. (TUI), found rendezvous conditions in which a space tether can reach the Boeing DF-9 hypersonic airplane without overheating its tip. DF-9 is similar to the X-43 research vehicle scheduled to fly in summer 2000 at Mach 10. It uses JP-fueled air-breathing turboramjets up to Mach 4.5, with slush-hydrogen and air/oxygen ram/scram engines above 4.5. The space tether uses Spectra polymer, and its zylon (PBO) tip warms only to 40°C during aeropass. The tether facility can restore its spin and orbit energy after each payload pickup by using electrodynamic propulsion and tether length pumping, which require solar energy but no propellant, while the grapple requires only a little propellant for each rendezvous.

In Phase II, we will study technology issues and identify solutions. Subsystem simulation models will be improved and coupled to find the combination that provides reliable payload transfer at low cost. We will identify potential users and upcoming flight mission opportunities, developing variations on the basic architecture to match the users and missions. This will result in a technology roadmap that shows how the HASTOL architecture can be developed through a series of technology and flight demonstrations.

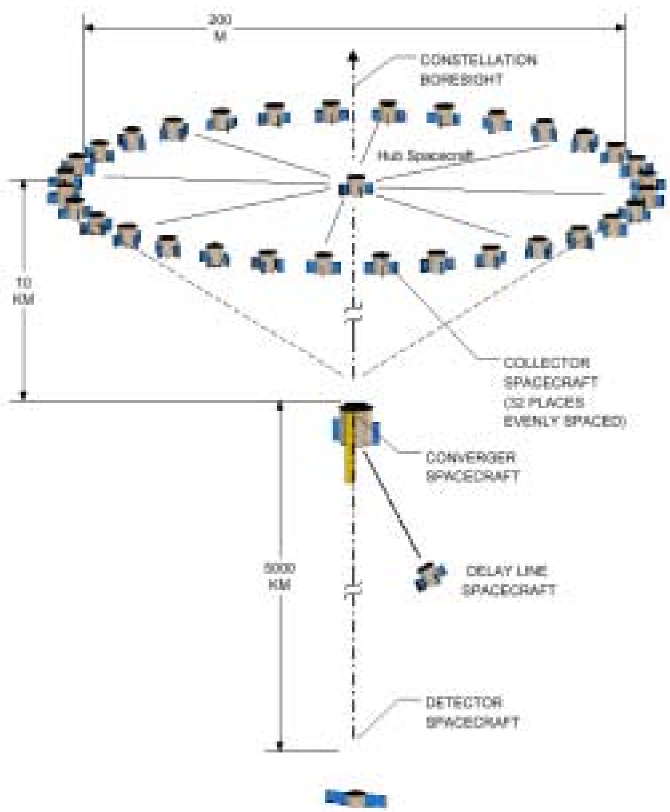


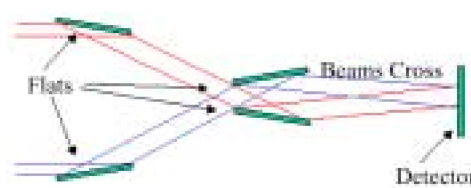


X-ray Interferometry

WEBSTER CASH
University of Colorado

The x-ray band of the spectrum is the natural band for ultra-high resolution imaging. The sources have high surface brightness, the features are unusually compact, and the short wavelengths allow high resolution in relatively small instruments. In Phase I we reviewed the scientific potential of x-ray interferometry and showed how spatial resolution a billion times finer than HST's can be achieved in the foreseeable future. That extraordinary improvement in resolution will enable new probes of extreme environments like the warped space-time regions above the event horizons of black holes. We present an instrument design concept for the observatory, set the mission requirements and tabulate the instrument tolerances. We have studied the component technologies that are needed to assemble a full mission. We have uncovered the limitations on the eventual spatial resolution and show how the system can function down to a nano-arcsecond and below. It is our purpose to make a convincing case to both NASA and the science community that this advanced concept is of use in future missions. With the additional study proposed for Phase II it should be possible to fully demonstrate a reliable technical pathway to the launch of an exciting new class of scientific mission.





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Abstracts and Graphics

Planetary Exploration Using Biomimetics

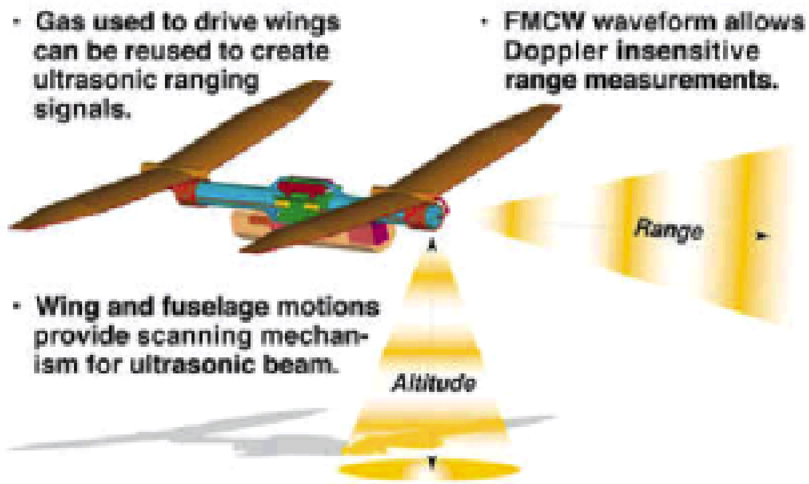
ANTHONY COLOZZA
Ohio Aerospace Institute

The Mars environment, particularly the low atmospheric density, makes flight much more difficult than on Earth, requiring an aircraft to fly within a very low Reynolds number/high Mach number regime. A possible solution is the use of an entomopter, a mechanical flying machine utilizing insect flight characteristics. Their similar Reynolds number flight regime indicates air vehicle system potential for future Mars exploration missions.

Insects are able to fly at a significantly higher Coefficient of Life (C_L) than conventional airplanes ($\sim C_L = 1$), due to their unique lift generation mechanisms. Utilizing these mechanisms as well as flow control over the wings, an entomopter can achieve lift coefficients from 5 to 8 times higher than those theoretically possible from the wing shape itself. This enhanced lifting capability could allow an entomopter to carry up to 15 kg of payload while flying at 30 m/s.

The Phase II program will involve investigation of the aerodynamics, appropriate propulsion methods, Mars compatible propellants, and the potential for fuel synthesis from indigenous materials. Autonomous and self-stabilizing behavior and control will be investigated for flight operations, refueling, communications, and navigation. The existing body of knowledge from terrestrial applications research and patents will be leveraged to enhance the vehicle's capabilities.

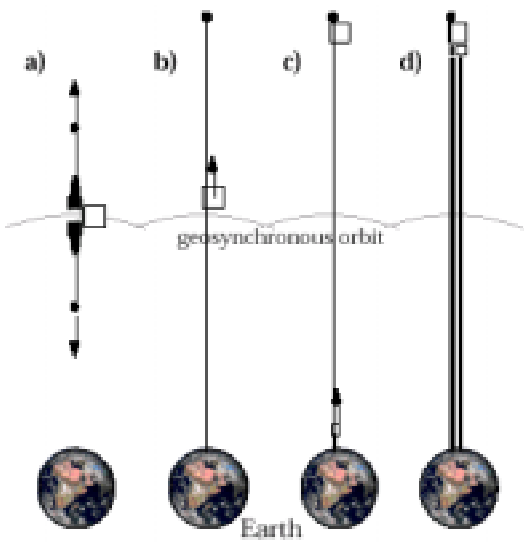
An entomopter based exploration vehicle system with *in situ* generated refueling could provide a flexible system for long duration exploration of the Mars surface. A 1 m. wingspan entomopter may be an elegant and practical architecture to produce a vehicle with the ability to take off, land, return samples, and even hover, providing significant mission capability enhancements over conventional aircraft.

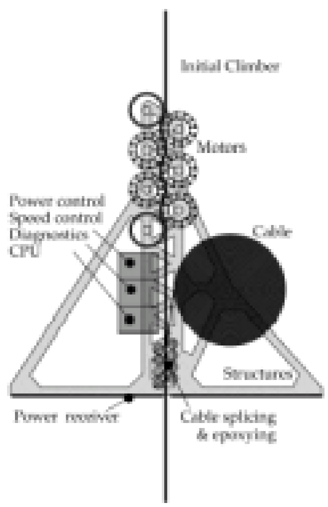


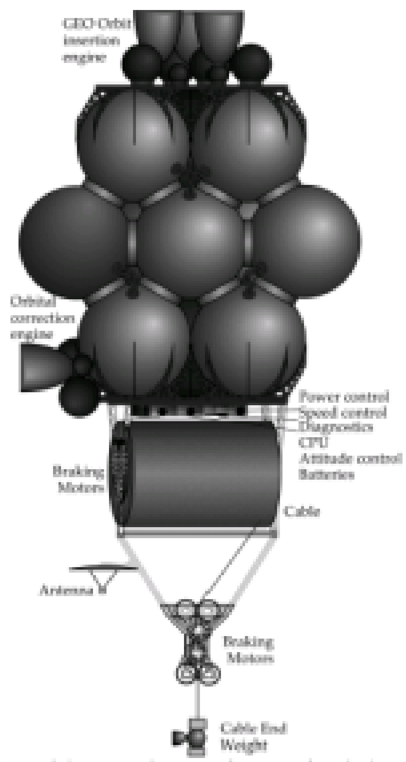
The Space Elevator

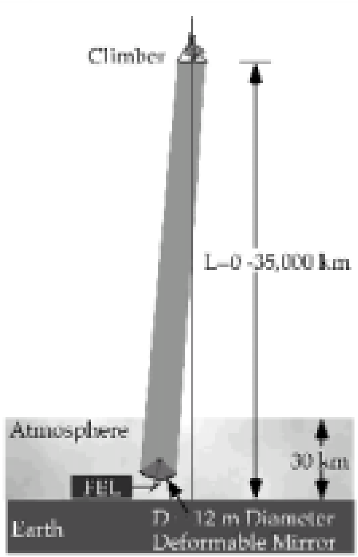
BRADLEY CARL EDWARDS
Eureka Scientific

Currently NASA and all space agencies are completely dependent on rockets to get into space. Several advanced propulsion systems are being examined by NASA and others, but few, if any, of these technologies, even if perfected, can provide the high-volume, low-cost transportation system that will be required for the future space activities mankind hopes for. A system that may have the required traits is the one that we examined in our Phase I, the space elevator. The space elevator, a cable that can be ascended from Earth to space, is unlike any other transportation system for getting into space. Our Phase I laid down the technical groundwork examining all aspects of a proposed first elevator, but was unable to test many of the designs and scenarios proposed. The hurdles were found and the technology requirements for the system quantified. Even we, the proposers, were surprised by the apparent feasibility of the space elevator, the availability of almost all of the required technology, and the affordability of the first elevator. Our Phase II effort is the critical next step. It will begin to answer many of the questions that remain, provide direction for future research and be crucial for future funding and programmatic decisions. In Phase II we will construct cable segments from carbon nanotube composites and test their general characteristics as well as their resistance to meteor and atomic oxygen damage. We will examine critical aspects of the space elevator design such as the anchor and power beaming systems, cable production, environmental impact, the budget and the major design trade-offs. Our previous work along with our Phase II results will then be introduced into the NASA mainstream effort through a conference and publication.









Methodology for the Study of Autonomous VTOL Scalable Logistics

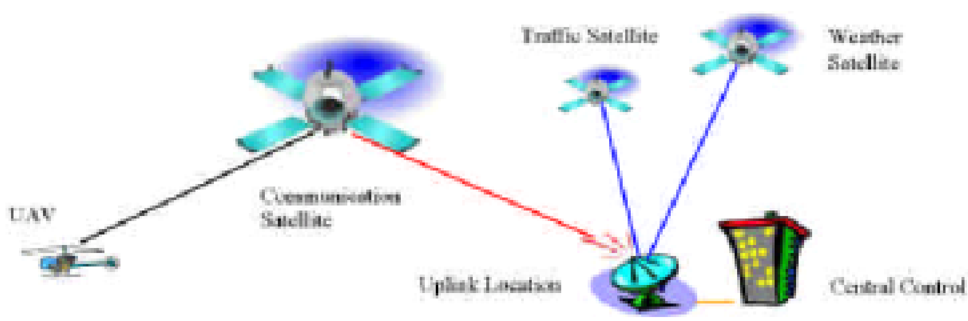
ANDY KEITH

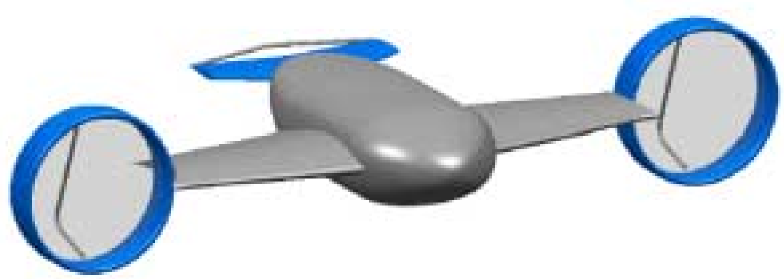
Sikorsky Aircraft Corporation

Substantial and promising results have been obtained by Sikorsky Aircraft during a NIAC Phase I study of an Autonomous VTOL Scalable Logistics Architecture (AVSLA). AVSLA is envisioned to be a future cargo delivery "system-of-systems" that provides cheaper, more efficient, and more effective service to the nation's consumers. Related VTOL vehicles for military heavy-lift purposes are also likely to benefit from AVSLA technology. The stated goal of the NIAC Phase II program is to provide a sound basis for NASA to use in considering advanced concepts for future missions. Thus, this Phase II proposal focuses on specific, critical research areas identified for AVSLA. The overall technical objective is to develop a system-of-systems model of the AVSLA design space, complete with supporting analyses in key areas that, when combined with advanced feasibility/viability determination methods, can establish a solid basis for a full-scale research program at NASA. In addition, a successful research program could be leveraged by Sikorsky Aircraft to obtain other funding in support of the development of an AVSLA.

Several areas critical to transforming AVSLA from an idea to reality were identified in Phase I. These technology areas include on-board vehicle computing functions (including communication, navigation, and safety), reliable autonomous control, air traffic management (ATM) system integration, and transportation architecture scalability. The Phase II effort proposed here provides the framework and steps for examining feasibility and viability of alternative AVSLA concepts and identification and assessment of the necessary new technologies in these areas. Research of these technology areas requires much more effort than possible in the NIAC Phase II. Thus, with the likely benefits of a deployable, efficient AVSLA established, these areas could form the basis of NASA research programs aimed at support for future systems. Missions enabled by AVSLA, including efficient, cost-effective package delivery and unique military tasks, are extremely important to the nation from economic, environmental, and national security points-of-view.

The Sikorsky-led Phase II team (a pairing of Sikorsky with the Georgia Institute of Technology) brings unique scientific and technical capabilities required to properly characterize the AVSLA system-of-systems design space. These unique capabilities lie in three critical areas: 1) system design methodologies, focused on future concept development and the probabilistic evaluation of new technologies and overall affordability, 2) systems dynamics and VTOL vehicle modeling, and 3) access to key expertise across the relevant disciplines and domains.



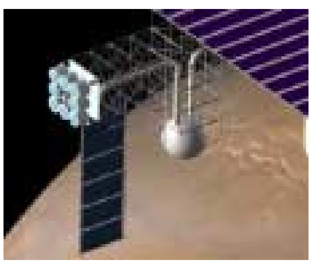


Cyclical Visits to Mars via Astronaut Hotels

KERRY T. NOCK
Global Aerospace Corporation

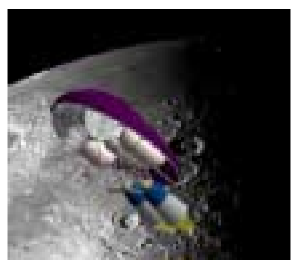
Global Aerospace Corporation is developing a revolutionary concept for an overall interplanetary rapid transit system architecture for human transportation between Earth and Mars which supports a sustained Mars base of 20 people circa 2035. This innovative design architecture relies upon the use of small, highly autonomous, solar-electric-propelled space ships, we dub *Astrotels* for **astro**naut ho**tels** and hyperbolic rendezvous between them and planetary transport hubs using even smaller, fast-transfer, aeroassist vehicles we call Taxis. Astrotels operating in cyclic orbits between Earth, Mars and the Moon and Taxis operating on rendezvous trajectories between Astrotels and transport hubs or Spaceports will enable low-cost, low-energy, frequent and short duration trips between these bodies. This proposed effort provides a vision of a far off future which establishes a context for near-term technology advance, systems studies, robotic Mars missions and human spaceflight. In this fashion Global Aerospace Corporation assists the NASA Enterprise for Human Exploration and Development of Space (HEDS) in all four of its goals, namely (1) preparing to conduct human missions of exploration to planetary and other bodies in the solar system, (2) expanding scientific knowledge, (3) providing safe and affordable access to space, and (4) establishing a human presence in space. Key elements of this innovative, new concept are the use of:

1. Five month human flights between Earth and Mars on cyclic orbits,
2. Small, highly autonomous human transport vehicles or Astrotels,
    - In cyclic orbits between Earth and Mars
    - Solar Electric Propulsion for orbit corrections
    - Untended for more than 20 out of 26 months
    - No artificial gravity
3. Fast-transfer, aeroassist vehicles, or Taxis, between Spaceports and the cycling Astrotels,
4. Low energy, long flight-time orbits and unmanned vehicles for the transport of cargo
5. in situ resources for propulsion and life support
6. Environmentally safe, propulsion/power technology

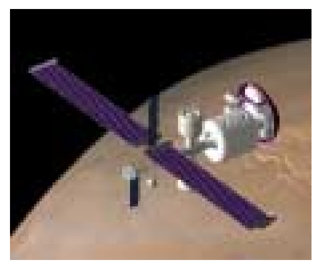


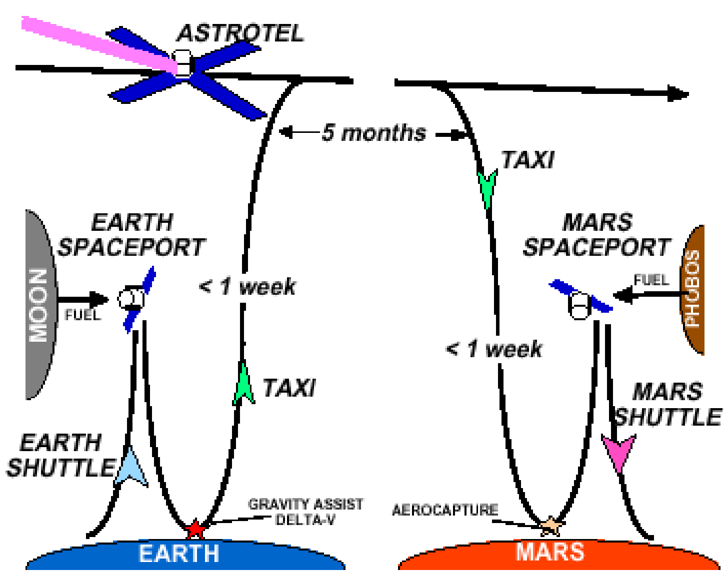
Astrotel IPS

Taxi during Mars Aerocapture



Taxi departing





Illustrates a schematic of the overall concept for regular human visits to Mars via an Astrotel concept that uses cyclic interplanetary orbits.

Exploration of Jovian Atmosphere Using Nuclear Ramjet Flyer

GEORGE MAISE

Plus Ultra Technologies, Inc.

We propose continued investigation of the design, operation, and data gathering possibilities of a nuclear-powered ramjet flyer in the Jovian atmosphere. The MITEE nuclear rocket engine can be modified to operate as a ramjet in planetary atmospheres. (Note: MITEE is a compact, ultra-light-weight thermal nuclear rocket which uses hydrogen as the propellant.) To operate as a ramjet, MITEE requires a suitable inlet and diffuser to substitute for the propellant that is pumped from the supply tanks in a nuclear rocket engine. Such a ramjet would fly in the upper Jovian atmosphere, mapping in detail temperatures, pressures, compositions, lightning activity, and wind speeds. The nuclear ramjet could operate for months because: 1) the Jovian atmosphere has unlimited propellant, 2) the MITEE nuclear reactor is a (nearly) unlimited power source, and 3) with few moving parts, mechanical wear should be minimal. During Phase I of this project, we developed a conceptual design of a ramjet flyer and its nuclear engine. The flyer incorporates a swept-wing design with instruments located in the twin wing-tip pods (away from the radiation source and readily shielded). The vehicle is 2 meters long with a 2 meter wingspan. Its mass is 220 kg, and its nominal flight Mach number is 1.5. Based on combined neutronic and thermal/hydraulic analyses, we calculated that the ambient pressure range over which the flyer can operate to be from about 0.04 to 4 (terrestrial) atmospheres. This altitude range encompasses the three uppermost cloud layers in the Jovian atmosphere: 1) the entire uppermost visible NH_3 ice cloud layer [where lightning has been observed], 2) the entire NH_4HS ice cloud layer, and 3) the upper portion of the H_2O ice cloud layer. To continue the validation of the ramjet flyer concept, additional work is required in several areas. These include a detailed study of radiation effects on instruments, flight stability of the vehicle in the highly turbulent Jovian atmosphere, data storage and transmission.